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THINNING ON STEEP TERRAIN WITH LOW-COST CABLE YARDERS

Final Report

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THINNING ON STEEP TERRAIN WITH LOW-COST CABLE YARDERS

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Project Scope: This project investigated, demonstrated, and analyzed three low-cost cable yarding systems suitable for removing full trees from forest thinning operations on steep terrain. We used a cable winch that attached to the three-point hitch of a conventional farm tractor to yard short slopes under 200 feet long. The Bitterroot Miniyarder and the Clearwater Yarder, both developed by the Missoula Equipment Development Center of the USDA Forest Service, were used on slopes up to 600 feet long. The trees were manufactured into a range of products, including full-tree chips for boiler fuel, conventional firewood, posts, poles, rails, and pulpwood.

DISCLAIMER

ABSTRACT

This project was intended to demonstrate and test the feasibility of using small cable systems to remove small trees from steep terrain in full-tree thinning operations. Many ranchers, farmers, and woodlot owners do their own thinning; because of this we tested equipment that could be used with farm machinery, or shop built, or purchased at relatively low cost. Normally, precommercial thinning is costly and the benefits of thinning accrue from the increased growth of the residual stand and the reduced potential of fire and insect damage. We collected detailed cost and yield data on these systems to determine if the value of the products removed would offset all or a portion of the thinning costs. Owners of small woodlots can use the data from our demonstration plots to decide if similar techniques and machinery could be used to improve their land and if that would be affordable.

There were six treatment plots in a variety of timber types, including ponderosa pine, lodgepole pine, and western larch. The plots were chosen for timber size, terrain, and their accessibility for demonstration purposes. We used a Pacific Model 500S tractor winch to yard short slopes under 200 feet long. We used the Bitterroot Miniyarder to yard longer slopes in lodgepole pine and western larch thinnings and in a lodgepole clearcut. For comparison we tested the larger Clearwater yarder in both a lodgepole pine thinning and a clearcut. On all treatment plots, the trees were directionally felled, and then yarded to a point where they could be moved to a processing area with a grapple-equipped farm tractor. The full trees were either chipped at the landing for hogfuel or processed into poles, rails, firewood, or pulpwood.

The following conclusions can be drawn from the project.

1. The equipment proved easy to set up, operate, and maintain, and it ran with a minimum of downtime.

2. Production rates varied with the size of timber and the type of silvicultural prescription. The highest production rates were obtained in the lodgepole pine clearcut.

3. Current values for hogfuel, firewood, and pulp logs are not always sufficient to cover the entire cost of thinning.

4. The most economical way to operate these systems is in thinning stands of six- to ten-inch diameter trees with a small crew.

5. Accessory equipment such as breakaway blocks and skyline tiebacks increases the efficiency of the Miniyarder.

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Project Planning

Thinning can significantly increase the productivity of forest land by encouraging growth of desirable trees. In most conventional thinnings, the felled trees are left to decompose slowly on the forest floor. However, during this period, the stand is more vulnerable to damage from fire and insects, and is also of little value for other uses such as grazing or recreation. Dense stands of lodgepole and ponderosa pine are extremely susceptible to severe outbreaks of the mountain pine beetle. Thinning the stand apparently deters the infestation by increasing the vigor of individual trees so that they can repel the attacking beetles. Many landowners must either perform costly precommercial thinning or risk losing the entire stand to the mountain pine beetle.

Since 1975, the Montana Forest and Conservation Experiment Station (MFCES) has been working to solve problems associated with conventional methods of thinning small trees. Lubrecht Forest personnel, in conjunction with adjoining private landowners and governmental agencies, have developed a full-tree thinning and utilization technique suitable for gentle terrain. In summary, this thinning method involves directionally felling the timber, putting the trees into piles, and removing the bunches to a central landing for processing. Depending on stem sizes and local markets, the trees can be manufactured into posts, poles, rails, firewood, or pulp logs, or chipped at the

landing for hogfuel to be used in industrial boilers. With the aid of grants from the Alternative Renewable Energy Sources Program and the Renewable Resources Development Program of the Montana Department of Natural Resources and Conservation (DNRC), the Lubrecht Forest has established a number of full-tree thinning demonstration plots. Approximately 586 landowners, small contractors, and professional foresters have viewed these plots. We also have published numerous reports and brochures containing production, yield, and cost data from these thinning plots.

Benefits of the full-tree removal and utilization thinning system include: (1) the thinned timber is processed into a marketable product that can be used to offset, either partly or completely, the cost of thinning; (2) the remaining trees have increased growth and increased value to the landowner; (3) the thinning slash is removed instead of becoming potential fuel for a fire; (4) or in the case of green thinning slash, the spread of harmful insects is reduced because this system removes the slash; (5) the landowner can easily re-enter the stand to remove other products and is therefore able to respond quickly and efficiently to changing market conditions; (6) growth of understory vegetation is enhanced when the slash is removed, which increases the forage available to domestic livestock or wildlife; (7) the removal of the thinned trees leaves the stand more accessible for recreational pursuits such as hunting and hiking; (8) many people think that a slash-free stand is more aesthetically pleasing and (9) full-tree thinning yields more raw material for products.

Although the full-tree thinning/utilization system was a viable method of treating stands of small timber, it was restricted to gentle or moderately sloping terrain. The small equipment used in this approach (mechanical feller-bunchers, farm tractors, and small rubber-tired skidders) could not be operated safely or effectively on slopes exceeding 25 percent. This study investigated and demonstrated potential systems that would make this technique work on steeper terrain and therefore be widely applicable in Montana. As in the previous work we wanted to emphasize inexpensive, portable, and flexible systems that landowners or small contractors could use or adapt to their individual situations.

Initial testing of equipment provided by the Intermountain Forest and Range Experiment Station (IFRES) and the Missoula Equipment Development Center (MEDC), both of the USDA Forest Service, led to development of a proposal to establish demonstration plots to test two types of equipment: the tractor winch and the small skyline yarder. These are suitable for yarding short and long slopes respectively. The proposal was submitted to Montana's DNRC for funding under the Renewable Resource Development Program. The project was recommended for funding by Montana DNRC, and the Forty-Eighth Montana Legislature approved the request and provided partial funding in 1983. Other financial support came from the Bonneville Power Administration (BPA) through their Biomass Utilization and Cogeneration Program and the Renewable Energy and Conservation Program, also administered by DNRC. Other study participants

included Potter Logging, Champion International Corporation, Montana Department of State Lands, the IFRES, and MEDC.

Description of Study Area

The general study area is the Lubrecht Experimental Forest, a property owned and administered by MFCES, which is the research arm of the School of Forestry, University of Montana, Missoula. Lubrecht Forest is on Highway 200 in the Blackfoot River valley approximately 30 miles northeast of Missoula. As a result of past logging, much of the forest is covered with second growth stands of ponderosa pine, Douglas fir, and western larch. On the eastern edge of the forest there are extensive stands of lodgepole pine, which were established following widespread wildfires in the mid-to-late 1800s. Elevations range from 3,200 feet along the Blackfoot River to 6,000 feet in the Garnet Range on the eastern edge of the forest. The terrain varies from gentle slopes along the river and the highway to steep hillsides in the Garnets. Much of the terrain is benchland with short, sharp pitches down to draws and intermittent streams. Weather records collected at the Forest Headquarters since 1958 show that the average annual precipitation is 17.91 inches, much of this in the form of snow.

The Lubrecht Forest is well suited for testing and showing these thinning techniques. First, because this area typifies much of the timberland in Montana, research results can be confidently projected to other areas of the state. Second, the forest is a research educational facility, so there will be

long-term protection for the demonstration plots. Third, the steep slope thinning units will complement other silvicultural studies on the forest. Fourth, Lubrecht has an excellent record of cooperation with adjacent private and public landowners and land managers. As a result, plots established on adjacent ownerships are afforded the same degree of protection and public access as those on Lubrecht.

There were six specific treatment plots; a detailed description of each unit is included in the appropriate milestone report in the appendices. Table 1 has a summary description of each unit and figure 1 shows its location on an area map.

Table 1. Summary Description of Treatment Plots

Plot No.	Milestone Report No.	Acres	Stand Type*	Equipment	Location
1	3	9.50	LPP	Miniyarder	Lubrecht
2	4	3.10	PP	Tractor Winch	Lubrecht
3	4	0.94	PP	Tractor Winch	Lubrecht
4	5	2.00	LPP	Miniyarder	DSL+
4a	9	0.73	LPP	Clearwater	DSL+
5	8	3.90	WL	Miniyarder	Lubrecht
6	9	3.30	LPP	Clearwater	Champion
6a	9	0.62	LPP	Miniyarder	Champion
	Total	24.09			

*LPP = Lodgepole pine; PP = Ponderosa pine; WL = Western larch
+DSL = Montana Department of State Lands

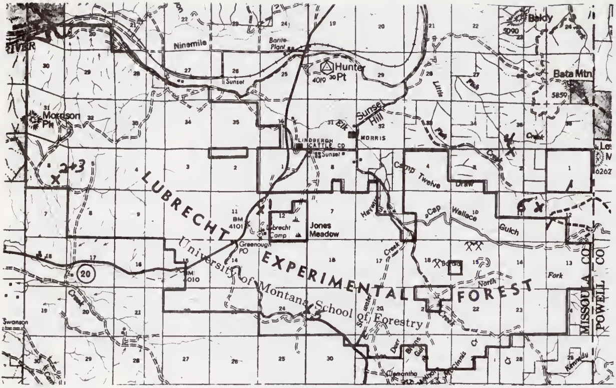

Figure 1. Lubrecht Experimental Forest Area Map

Scale: 1/2 inch = 1 mile
Treatment Plot Locations: X

Prior to treatment, each plot was systematically sampled using 1/20th-acre fixed permanent plots. Enough plots were established to obtain an allowable maximum sampling error of ten percent. At each sampling point each tree was measured at diameter breast high (DBH). Also a number of trees were measured for height to get a representative number per one-inch diameter class. The information was gathered for each species. The field data were processed through a computer program developed by the School of Forestry. The program output included the following information for each acre by species and one-inch diameter class: (1) number of trees, (2) basal area, (3) total stem cubic foot volume and (4) cubic foot volume to a four-inch top diameter. In each milestone report for the respective treatment plots we included a stand table for the

specific area. Each stand table lists by species for each one-inch DBH class the number of trees and total stem cubic foot volume on a per acre basis. For Treatment Plots 1, 2, 3, and 5 the permanent plots were remeasured following thinning to determine the average tree size and total cubic foot volume removed. We only sampled Plots 4 and 6 prior to treatment because in the first instance only the lodgepole pines were removed, and in the second instance, all the trees were removed. Although the complete inventory data for each treatment plot is not included in this report, the computer printouts for all the areas are part of the permanent records at Lubrecht, and are available to the public.

Description of Harvesting Systems

In the Milestone 1 report (Appendix A) we described in detail both the criteria for equipment selection and the alternatives examined. In summary, the equipment was selected on the basis of low initial cost, ease of operation, versatility, and portability. We tested both a Kolpe Radio Tir portable winch and also the Pacific tractor winch for yarding uphill and downhill on the short slopes. We chose the Pacific winch because of its lower initial cost, availability of spare parts, and the range of sizes commercially available. In addition, this unit has sufficient power to yard small sawlogs as well as bunches of smaller trees. We chose the Bitterroot Miniyarder and the Clearwater yarder primarily because they were both available locally, and we could use them free of charge.

However, the Clearwater is similar to other commercial yarders of the same size category that are available in the northern Rocky Mountain region. The Bitterroot is the only yarder of its size available in the country, and it also met all the requirements for small tree removal. In addition to the yarders, we used a grapple-equipped farm tractor for moving the material to the landings and processing areas. On Treatment Plot 6, we used a John Deere Model 440G rubber-tired skidder for this swing function. A Morbark Model 12 Chiparvestor was used to manufacture full-tree chips on Plots 1, 2, 3, and 5. The detailed specifications for all equipment used are listed in Appendix H. Table 2 summarizes the type of equipment used on each treatment block.

Table 2. Equipment Used by Treatment Plot

Plot No.	Bitterroot Miniyarder	Clearwater Yarder	Tractor Winch	Grapple Tractor	440	Model 12 Chipper
1	x			x		x
2			x	x	x	x
3			x	x	x	x
4	x	x(4a)		x	x	
5	x			x		x
6	x(6a)	x		x	x	

Milestone 2 (Appendix B) describes in detail the thinning system including equipment, crew, and techniques used in this project. Specific information for each treatment plot is listed in the appropriate milestone report (Appendices C-G). However, it may be helpful to briefly discuss the elements common to all the plots. The treatment on each unit usually consisted of four

stages--felling and bunching, yarding, swing, and processing. The size of the crew changed according to the work done on each treatment plot. However, in most cases, the crew would fell and bunch the material, and then do the yarding, swing, and processing phases. On Plots 2, 3, and a part of 5, the processing was done after the yarding and swing phases.

In the felling and bunching step, a crew of two or three people felled the timber with the butts facing the yarding corridor. In timber under four inches DBH, the crew would bunch the trees into piles so that multiple stems could be removed with one choker. Whenever possible, the crew would group the larger trees to minimize choker setting. In most cases, the trees were felled before yarding. However, on parts of Plots 1 and 4, falling and yarding was done at the same time. Although this approach was efficient on Plot 1 where we left a dense residual stand, it was not effective on Plot 4 where the residual stand was more open. On Plot 4 the felling and yarding crews tended to interfere with one another. In general, a two-person felling crew consisting of a sawyer and a pusher/stacker was the most efficient.

The second phase was yarding. Depending on the specific site and type of machine used, the crew consisted of from two to four people. Three people operated the tractor winch on Treatment Plots 2 and 3. One person operated the tractor winch while the other two pulled cable and set chokers. The four-person crew was used part of the time with the Clearwater yarder on Plot 6. The Miniyarder crews varied from two to three

people. On the yarders, one person operated the machine and unhooked incoming turns. The remaining crew members were in the woods, and were responsible for setting chokers and breakaway blocks and moving the carriage stop. The yarder operator and woods crew communicated with small, voice-actuated FM radios. Usually the entire crew was involved in moving the yarder between corridors.

The swing phase involved moving the bunches of trees from the yarder to a landing area for processing and decking. One person operated a grapple-equipped farm tractor to perform this function on all the units except Treatment Plots 2, 3, 4a, and 6, where the operator used either a John Deere 540 or 440 skidder. The larger skidder was necessary to match the increased yarding capacity of the Clearwater on Plots 4 and 6. On Treatment Plot 5, where the trees were chipped into hogfuel, the tractor operator either heeled the material into shingle stacks for future processing or fed the chipper directly. The swing person also decked pulp logs and rails on units where those products were manufactured.

The crew and machinery involved in the processing step varied with the products generated. Two people, the chiparvestor, and grapple tractor were used on Treatment Plots 2, 3, and 5. On Plots 1, 4, and 6, one or two people limbed and bucked the trees on the landing. In some instances, depending on landing location, one of the landing crew or a third person used another tractor either to shingle stack material for chipping or to deck rails, poles, and pulpwood. As mentioned

previously, the swing person also assisted in decking material. The choice of end products was dictated by tree species and size, available landing space, condition of the road leading to the area, and the desires of the landowner.

Production Data

Table 3 lists in summary format the products recovered from each treatment plot. The hogfuel was all processed on site with a Morbark Model 12 Chiparvestor. On Treatment Plots 1, 2, and 3, the unit designation refers to a 200-cubic-foot volumetric unit. On Treatment Plot 5, the units are 2,400 pound oven-dry units. The poles and pulpwood were cut to a three- to four-inch top diameter inside bark.

Tables 4 through 8 compare the production data from the various treatment plots in summary format by operational phase. The basic record keeping unit that we measured in the field was stems per working hour. We counted all the trees cut and all the stems yarded and processed. We calculated the total stem cubic foot content of the average tree from the inventory data. The cubic foot production per hour was then obtained by multiplying the number of stems by the cubic foot content of the average stem. Working hours are defined as that time in which the crew or machine was engaged in thinning activity. It includes operational time (when the equipment or crew member was actually producing a product), equipment downtime, and time spent in associated activities such as moving and setting up the yarder. It does not include travel time, lunch breaks,

demonstrations or tours, and record keeping. The milestone reports list more detailed data, including production by operational hour compared to working hours, number of turns per hour, average yarding distance, and number of stems per turn.

Table 3. Summary of Products Removed from Each Treatment Plot

Plot No.	Product	Amount
1	Hogfuel	144.73 units 229 green tons
	Poles	904 pieces 3,762 cubic feet
2	Hogfuel	52.13 units 66 green tons
3	Hogfuel	21.48 units 28 green tons
4	Poles	999 pieces 7,031 cubic feet
4a	Pulpwood	406 pieces 3,260 cubic feet
5	Hogfuel	38.99 units 76 green tons
6	Pulpwood	2,130 pieces 17,697 cubic feet
	Sawlogs	5.330 MBF Scribner
6a	Pulpwood	388 pieces 2,949 cubic feet

Table 4. Felling and Bunching Production Summary

Plot No.	Total Stems	System Hours	Crew Size	Crew Member Hours	Stems/ System Hour	Stems/ Crew Member Hr	Cu Ft/ System Hour	Cu Ft/ Cr Mem Hour	Cu Ft Stem
1*	1,441	18.1	5	90.5	88	16	224	45	2.80
2	1,659	21.5	3	64.5	77	26	132	45	1.72
3*	925	17.0	2-3	42.5	55	22	78	31	1.42
4	969	39.5	2	79.0	25	12	201	99	8.03
4a	415	11.3	2	22.7	37	18	297	147	8.03
5	1,344	10.0	3	30.0	134	45	125	42	0.93
5(2)*	2,864	31.0	2	62.0	92	46	86	43	0.93
6*	2,177	31.8	2-3	74.4	68	29	564	241	8.30
6a*	301	3.7	4	14.8	81	20	616	152	7.60

* NOTES

1. These data are for a 3.5-acre portion of the plot where the material was felled and bunched prior to yarding.

3. These are combined times for the two- and three-person crews. The two-person crew worked half the time and the three-person crew the remaining half of the time. See Appendix D for differences in production between the crews.

5(2). This data from Treatment Plot 5 is for the three-person felling and bunching crew.

6. These are combined times for the two- and three-person crews. The two-person crew was used 75% of the time and the three-person crew the remaining 25%. See Appendix G for differences in production between the crews.

6a. The felling system consisted of two crews of two people each.

Table 5. Yarding Production Summary

Plot No.	Yarder	Total Stems	System Hours	Crew Size	Crew Member Hours	Stems/ System Hour	Stems/ Crew Member Hr	Cu Ft/ System Hour	Cu Ft/ Cr Mem Hour	Cu Ft Stem
1(1)	Mini	1,711	46.3	4	185.2	37	9.2	104	26	2.80
1(2)*	Mini	1,363	33.2	4	132.8	41	10.3	115	29	2.80
2	Winch	1,659	22.0	3	66.0	75	25.1	129	43	1.72
3	Winch	925	6.5	3	19.5	142	47.4	201	67	1.42
4*	Mini	1,330	52.7	3	137.7	25	9.7	201	78	8.03
4a	Clrwtr	486	10.3	3	31.0	39	13.1	313	105	8.03
5*	Mini	4,050	32.5	3	82.5	125	49.1	116	46	0.93
6*	Clrwtr	2,130	40.9	3-4	133.2	52	16.0	432	133	8.30
6a	Mini	388	15.0	2	32.1	26	12.1	198	92	7.60

* NOTES

1(2). On this portion of the plot the crew felled and bunched the trees simultaneously with the yarding. Because it was very difficult to separate functions, the times shown also include the felling and bunching function.

4. The total crew time is not the same as three times the system hours because, at times, the crew consisted of only two people.

5. The same as 4 above.

6. These are combined times for the three- and four-person crews. The four-person crew was only used 28% of the time and the three-person crew the remaining 72%.

Table 6. Swing Production Summary

Plot No.	Swing Machine	Total Stems	System Hours	Crew Size	Stems/ System Hour	Cu Ft/ System Hour	Cu Ft/ Tree
1*	80 hp Farm Tractor	3,074	34.0	0.50	98	252	2.80
2	50 hp Farm Tractor	1,659	8.4	0.80	197	339	1.72
3*	50 hp Farm Tractor	925	7.5	1.00	123	175	1.42
4*	80 hp Farm Tractor	1,330	11.5	0.25	116	931	8.03
4a*	Grapple Skidder	486	3.4	0.35	119	955	8.03
5	50 hp Farm Tractor	4,050	25.0	1.00	162	151	0.93
6*	Grapple Skidder	2,138	10.5	0.35	203	1,685	8.30
6a*	50 hp Farm Tractor	388	3.3	0.25	118	897	7.60

* NOTES

This table reflects only the time spent in moving material from the yarder to either the processing area or to a stockpile. On Treatment Plots 1, 4, and 6, the swing person also assisted with the processing phase. As a result, there are fractional crew sizes.

1. The tractor operator spent one-half of his time assisting in the processing phase. He stacked the small trees and tops into shingle stacks and also decked poles.

3. One person did both the swing and assisted with the processing at one time. Eighty percent of his time was allocated to swing and 20% to processing.

4. The tractor operator spent 25% of his time in the swing phase and 75% in the processing phase.

4a. The tractor operator spent 35% of his time in the swing phase and 65% in the processing phase.

6. The tractor operator spent 35% of his time in the swing phase and 65% in the processing phase.

6a. One person did both the swing and processing phase on this Treatment Plot. Twenty-five percent of his time was allocated to swing and 75% to processing.

Table 7. Processing Production Summary

Plot No.	Products	System Hours	Total Machine Hours	Crew Size	Total Crew Hours	Units/ System Hour	Units/ Crew Member Hr	Cu Ft/ System Hour	Cu Ft/ Cr Mem Hour
1	Poles	68.0	85.0	1.25	99.5	—	—	55	38
1*	Hogfuel	19.5	56.3	2.25	56.3	7.4	2.6	—	—
2*	Hogfuel	10.5	12.6	1.20	12.6	5.0	4.1	—	—
3*	Hogfuel	4.0	8.0	2.00	8.0	5.4	2.7	—	—
4	Poles	46.0	46.0	1.75	80.5	—	—	153	87
4a	Pulpwood	9.8	16.8	1.65	16.2	—	—	331	200
5*	Hogfuel	7.2	14.4	2.00	14.4	5.4	2.7	—	—
6*	Pulpwood	30.1	25.2	1.65	64.4	—	—	599	280
6a	Pulpwood	10.0	10.0	0.75	10.0	—	—	295	295

* NOTES

These data include time spent by the swing person in the processing function. As a result there are fractional crew sizes. In the original Milestone Reports, we did not allocate any of the swing person's time to processing.

1, 2, 3. The hogfuel units are volumetric 200 cubic-foot units.

2. One person did both the swing and assisted with the processing function. Eighty percent of his time was allocated to swing and the remaining 20% to processing.

4a. The pulpwood units are 2,400 pound oven-dry units.

5. The hogfuel units are 2,400 pound oven-dry units.

6. The data reflect an average of a one- to two-person processing crew plus the swing person. An extra processing person was used approximately 45% of the time.

6a. One person did both the swing and processing functions. Twenty-five percent of the time was allocated to swing and the remaining 75% to processing.

Table 8. Combined Production Summary

Plot No.	Yarder	Total Stems	Total System Hours	Tot. Crew Member Hours	Stems/ System Hour	Stems/ Crew Member Hr	Cu Ft/ System Hour	Cu Ft/ Cr Mem Hour	Cu Ft Stem
1	Mini	3,074	219.1	598.3	14.0	5.1	39.3	14.4	2.80
2	Winch	1,659	62.4	151.5	26.6	11.0	45.7	18.8	1.72
3	Winch	925	35.0	77.5	26.4	11.9	37.5	11.9	1.42
4	Mini	1,330	149.7	308.7	8.9	4.3	71.3	34.6	8.03
4a	Clwtr	406	34.8	73.3	11.7	5.5	93.7	44.5	8.03
5	Mini	4,050	105.7	213.9	38.3	19.0	35.6	17.6	0.93
6	Clwtr	2,130	113.3	282.5	18.8	7.5	156.0	62.6	8.30
6a	Mini	388	32.0	60.2	12.1	6.4	92.2	49.0	7.60

Table 8 gives the combined production for felling, yarding, swinging, and processing on each of the units. The effect of crew size, type of yarder, average tree size, and silvicultural prescription is evident when comparing production rates by cubic foot per crew member hour. The crew was most efficient on Treatment Plot 6 where they clearcut larger lodgepole pine, yarded with the Clearwater, and produced only pulpwood.

(This para. should go in the space before Table 8 on the previous page.)

Economic Evaluation

The economic evaluation consists of four sections. The first section identifies and explains the assumptions that form the basis of the calculations. The second section consists of a series of tables, one for each treatment plot. Each table summarizes labor and equipment costs for each phase of the operation for that particular unit. The costs are expressed in terms of total costs, cost per piece, cost per cubic foot, and cost per meter. The third part is a table depicting per acre and per hectare costs and revenues for each of the treatment plots. The fourth part discusses factors that are important to increasing net revenue when using these small cable systems.

The two major factors in the economic evaluation are the number of hours worked and the cost per hour for labor and equipment. As in the production data tables, working hours are used in the analyses. (Working hours are defined as that time in which the crew or machine was engaged in thinning or harvesting.) It included operational time (when the equipment or crew member was actually producing a product), equipment downtime, and time spent in associated activities such as moving and setting up the yarder. It does not include such items as travel, lunch breaks, demonstrations or tours, and record keeping. Also omitted from the calculations are overhead and administration for treatment plot reconnaissance and inventory or data processing.

Figures for labor and machinery vary widely. Readers should assign those labor and equipment costs that are applicable to

their individual situations. The danger of reporting cost data is that people will often look only at the bottom line cost data without examining or remembering the cost per hour assumptions. Labor costs in particular will fluctuate widely. For example, a hired hand thinning on ranch property may be paid only $5.00 per hour, with minimal additional benefits paid by the rancher. However, the employee may receive free housing, utilities, some ranch products, and so forth. By contrast, the average hourly rate for a corporate woods worker in Montana is approximately $12.00, and the employer pays an additional 40% for a health insurance and benefit package that totals $22.40 per hour. Obviously, the economic feasibility of a forest thinning operation will be greatly affected if the labor costs vary by a factor of four.

With this in mind, we have listed in table 9 the hourly costs of labor and equipment that were used in the economic evaluation of the treatment plots. The labor rate in table 9 is fairly low but may be valid for the types of individuals and organizations doing the work, that is, ranchers, woodlot owners, and small, independent contractors. The labor costs include both salary and benefits. Because individual crew members typically perform a variety of functions in this type of operation, a uniform hourly rate was used. The equipment costs reflect the fact that most landowners and small contractors operate their own equipment, perform higher than average preventive maintenance, and depreciate the machinery over a longer time period. The equipment costs do not include operator wages.

Table 9. Hourly Labor and Equipment Costs

Item	Rate
Labor	$ 7.50
John Deere Model 2940 FWD Farm Tractor	8.75
John Deere Model 2240 FWD Farm Tractor	8.00
John Deere Model 2240 FWD Farm Tractor Winching	5.00
John Deere Model 440G Rubber-tired Skidder	20.00
John Deere Model 540G Rubber-tired Skidder	27.00
Morbark Model 12 Chiparvestor	28.00
Clearwater Yarder	16.20
Bitterroot Miniyarder	7.10
Chainsaws	1.50

Tables 10(1) through 10(6a) summarize labor and equipment costs for each phase of the operation for that particular unit. The costs are expressed in terms of total cost, cost per piece, cost per cubic foot, cost per cubic meter and, where appropriate, cost per unit of hogfuel. The hogfuel units in tables 10(1), 10(2), and 10(3) are 200-cubic foot units, whereas in table 10(5) they are 2,400-pound oven-dry units.

Table 10(1). Labor and Equipment Costs, Treatment Plot 1

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M
Felling and Bunching*				
Labor	$ 678.75	$ .471	$ .168	$ 5.94
Equipment	27.15	.019	.006	.24
Total	$ 705.90	$ .490	$ .174	$ 6.18
Yarding				
Labor	$2,385.00	$ .776	$ .277	$ 9.79
Equipment	600.00	.195	.070	2.46
Total	$2,985.00	$ .971	$ .347	$12.25
Swing				
Labor	$ 255.00	$ .083	$ .029	$ 1.05
Equipment	297.50	.097	.035	1.22
Total	$ 552.50	$ .180	$ .064	$ 2.27
Processing				
Labor	$1,168.50	$ .380	$ .136	$ 4.80
Equipment	1,689.08	.549	.196	6.93
Total	$2,857.58	$ .929	$ .332	$11.73
GRAND TOTAL	$7,100.98	$2.57	$ .94	$32.43

*These data are for a 3.5-acre portion of the plot where the material was felled and bunched before yarding. The trees on the remainder of the plot were felled concurrently with yarding.

Table 10(2). Labor and Equipment Costs, Treatment Plot 2

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M	Cost/ Unit
Felling and Bunching					
Labor	$ 483.75	$ .292	$ .169	$ 5.97	$ 9.28
Equipment	32.25	.019	.011	.39	.62
Total	$ 516.00	$ .311	$ .180	$ 6.36	$ 9.90
Yarding					
Labor	$ 495.00	$ .298	$ .173	$ 6.11	$ 9.50
Equipment	110.00	.066	.039	1.38	2.11
Total	$ 605.00	$ .364	$ .212	$ 7.49	$11.61
Swing					
Labor	$ 63.00	$ .038	$ .022	$ .78	$ 1.21
Equipment	226.80	.137	.079	2.79	4.35
Total	$ 289.80	$ .175	$ .101	$ 3.57	$ 5.56
Processing					
Labor	$ 94.50	$ .057	$ .033	$ 1.17	$ 1.81
Equipment	350.70	.211	.123	4.34	6.73
Total	$ 445.20	$ .268	$ .156	$ 5.51	$ 8.54
GRAND TOTAL	$1,856.00	$1.12	$ .65	$22.93	$35.61

Table 10(3). Labor and Equipment Costs, Treatment Plot 3

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M	Cost/ Unit
Felling and Bunching					
Labor	$ 318.75	$ .345	$ .243	$ 8.59	$14.84
Equipment	25.50	.027	.019	.67	1.19
Total	$ 344.25	$ .372	$ .262	$ 9.26	$16.03
Yarding					
Labor	$ 146.25	$ .158	$ .111	$ 3.92	$ 6.81
Equipment	32.50	.035	.025	.88	1.51
Total	$ 178.75	$ .193	$ .136	$ 4.80	$ 8.32
Swing					
Labor	$ 56.25	$ .061	$ .043	$ 1.52	$ 2.62
Equipment	55.50	.060	.042	1.48	2.58
Total	$ 111.75	$ .121	$ .085	$ 3.00	$ 5.20
Processing					
Labor	$ 60.00	$ .065	$ .046	$ 1.63	$ 2.79
Equipment	220.00	.238	.167	5.90	10.24
Total	$ 280.00	$ .303	$ .213	$ 7.53	$13.03
GRAND TOTAL	$ 914.75	$ .990	$ .700	$24.59	$42.58

Table 10(4). Labor and Equipment Costs, Treatment Plot 4

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M
Felling and Bunching*				
Labor	$ 592.50	$ .611	$ .076	$ 2.69
Equipment	59.25	.061	.008	.27
Total	$ 651.75	$ .672	$ .084	$ 2.96
Yarding				
Labor	$1,032.75	$ .776	$ .096	$ 3.42
Equipment	369.72	.278	.035	1.22
Total	$1,402.47	$1.054	$ .131	$ 4.64
Swing				
Labor	$ 86.25	$ .065	$ .008	$ .28
Equipment	100.62	.075	.009	.33
Total	$ 186.87	$ .140	$ .017	$ .61
Processing				
Labor	$ 603.75	$ .454	$ .056	$ 2.00
Equipment	471.50	.354	.044	1.56
Total	$1,075.25	$ .808	$ .100	$ 3.56
GRAND TOTAL	$3,316.34	$2.670	$ .330	$11.77

*These data are for a portion of the plot only. The felling and bunching costs for the remaining area are included in the yarding data.

Table 10(4a). Labor and Equipment Costs, Treatment Plot 4a

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M
Felling and Bunching				
Labor	$ 170.25	$ .410	$ .051	$ 1.80
Equipment	16.95	.041	.005	.18
Total	$ 187.20	$ .451	$ .056	$ 1.98
Yarding				
Labor	$ 232.50	$ .573	$ .070	$ 2.46
Equipment	160.78	.396	.048	1.70
Total	$ 393.28	$ .969	$ .118	$ 4.17
Swing				
Labor	$ 25.50	$ .063	$ .008	$ .27
Equipment	68.00	.167	.020	.72
Total	$ 93.50	$ .230	$ .028	$ .99
Processing				
Labor	$ 121.50	$ .299	$ .037	$ 1.29
Equipment	228.45	.563	.068	2.42
Total	$ 349.95	$ .862	$ .105	$ 3.71
GRAND TOTAL	$1,023.93	$2.510	$ .310	$10.85

Table 10(5). Labor and Equipment Costs, Treatment Plot 5

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M	Cost/ Unit
Felling and Bunching					
Labor	$ 690.00	$ .170	$ .183	$ 6.47	$17.69
Equipment	61.50	.015	.016	.58	1.58
Total	$ 751.50	$ .185	$ .199	$ 7.05	$19.27
Yarding					
Labor	$ 618.75	$ .153	$ .164	$ 5.80	$15.87
Equipment	217.40	.053	.058	2.04	5.57
Total	$ 836.15	$ .206	$ .222	$ 7.84	$21.44
Swing					
Labor	$ 187.50	$ .046	$ .050	$ 1.76	$ 4.81
Equipment	200.00	.049	.053	1.87	5.13
Total	$ 387.50	$ .095	$ .103	$ 3.63	$ 9.94
Processing					
Labor	$ 108.00	$ .027	$ .028	$ 1.01	$ 2.77
Equipment	259.20	.091	.097	3.44	9.42
Total	$ 367.20	$ .118	$ .125	$ 4.45	$12.19
GRAND TOTAL	$2,342.35	$ .600	$ .650	$22.97	$62.84

Table 10(6). Labor and Equipment Costs, Treatment Plot 6

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M
Felling and Bunching				
Labor	$ 558.00	$ .256	$ .031	$ 1.09
Equipment	47.70	.022	.003	.09
Total	$ 605.70	$ .278	$ .034	$ 1.18
Yarding				
Labor	$ 999.00	$ .469	$ .055	$ 1.95
Equipment	619.24	.291	.034	1.21
Total	$1,618.24	$ .760	$ .089	$ 3.16
Swing				
Labor	$ 78.75	$ .037	$ .004	$ .15
Equipment	210.00	.098	.012	.41
Total	$ 288.75	$ .135	$ .016	$ .56
Processing				
Labor	$ 483.00	$ .227	$ .027	$ .94
Equipment	486.15	.228	.027	.85
Total	$ 969.15	$ .455	$ .054	$ 1.79
GRAND TOTAL	$3,481.84	$1.628	$ .193	$ 6.69

Table 10(6a). Labor and Equipment Costs, Treatment Plot 6a

	Total Costs	Cost/ Stem	Cost/ Cu Ft	Cost/ Cu M
Felling and Bunching				
Labor	$ 111.00	$ .360	$ .048	$ 1.71
Equipment	11.10	.037	.005	.17
Total	$ 122.10	$ .406	$ .053	$ 1.88
Yarding				
Labor	$ 240.75	$ .620	$ .081	$ 2.88
Equipment	102.76	.265	.035	1.23
Total	$ 343.51	$ .885	$ .116	$ 4.11
Swing				
Labor	$ 24.75	$ .064	$ .008	$ .30
Equipment	26.40	.068	.009	.31
Total	$ 51.15	$ .132	$ .017	$ .61
Processing				
Labor	$ 75.00	$ .193	$ .025	$ .90
Equipment	80.00	.206	.027	.96
Total	$ 155.00	$ .399	$ .052	$ 1.86
GRAND TOTAL	$ 671.76	$1.821	$ .024	$ 8.46

Table 11 summarizes the costs and revenues per acre and per hectare for each of the treatment plots. The cost data were taken from tables 10(1) through 10(6a). Revenue was based on current market values for the range of products removed. The hogfuel from Treatment Plots 1, 2, and 3 was measured in 200-cubic-foot units and had a value of $16.00 per unit when blown into the back of a van. By contrast, the hogfuel from Treatment Plot 5 was measured in bone-dry units and had a value of $24.00 per unit when blown into the van. For uniformity, all other products (with the exception of sawlogs) were considered pulpwood, with 86.6 solid cubic feet of wood or 2.2 green tons being equivalent to one bone-dry unit of pulp chips. The current value of pulpwood delivered to Missoula is $18.00 per green ton or $450.00 for a 25-ton truckload. The average loading and hauling cost from the treatment plots to Missoula would be $140.00 per truckload or $5.60 per ton. The value of the pulpwood on the deck was calculated at $12.40 per ton or $27.28 per bone-dry unit (86.6 cubic feet of solid wood). We also removed 5,330 board feet of sawlogs from Treatment Plot 6 at an average value of $89.31 per thousand board feet.

Table 11. Cost and Revenue Per Acre and Hectare by Treatment Plot

Plot No.	Acres	Total Cost	Total Revenue	Cost/ Acre	Revenue/ Acre	Cost/ Hectare*	Revenue/ Hectare*
1	7.67	$7,162.99	$3,500.72	$ 933.90	$ 456.42	$2,307.76	$1,127.86
2	3.10	1,856.00	834.08	598.71	269.06	1,479.47	664.87
3	0.94	914.75	343.68	973.14	365.62	2,404.73	903.48
4	2.00	3,316.34	2,214.86	1,658.17	1,107.43	4,097.50	2,736.57
4a	0.73	1,023.93	1,026.82	1,402.64	1,406.60	3,466.06	3,475.85
5	3.90	2,342.35	1,052.73	600.60	296.93	1,484.14	667.02
6	3.30	3,481.84	5,501.00	1,055.10	1,666.97	2,607.26	4,119.25
6a	0.62	671.76	928.88	1,083.48	1,498.19	2,667.39	3,702.18

* One hectare is equivalent to 2.4711 acres.

NOTE: Only 7.67 acres of the total 9.5 acres were thinned in Treatment Plot 1. The remaining 1.83 acres were left as a control area.

Table 11 shows that revenue was equal to or greater than cost only on Treatment Plots 4a, 6, and 6a. There are common factors on these plots that contributed to the favorable revenue/cost ratio, and are also important to increase general net revenue. First, the size of the average tree removed was relatively large, from 7.6 to 8.3 cubic feet per stem, which is equivalent to a tree 6.0 inches in diameter at breast height and 60 feet tall. Second, the Clearwater Yarder was used on two of the three plots. With the larger machine we were able to increase our payload per unit of time yarding.

Using the Clearwater also reduced our felling and bunching time, because we did not have to buck the larger trees into pieces to remove them from the woods. Third, on Plot 6a in particular, we kept the crew size to an absolute minimum, which reduced costs. Fourth, because lodgepole pine pulpwood was the major product from these units, processing on the landing was minimal. Fifth, the silvicultural prescriptions on the three units enhanced production--a wide spacing for the thinning on Plot 4a and a clearcut on Plots 6 and 6a. Clearcut harvesting in particular speeded production because we did not have to use breakaway blocks to minimize damage to the residual stand.

In contrast, the plots in which cost greatly exceeded revenue were characterized by small tree sizes, denser residual spacing, and a variety of final products. These factors lowered production rates because of the following factors.

1. We had to handle more stems per unit of volume.
2. We had to take more care (time) to ensure minimal damage to the residual stand.
3. Processing took longer when a number of products were manufactured on the same landing.

On those plots where we used the Bitterroot Miniyarder, production was reduced because of the smaller load per turn or by the extra bucking required in the woods prior to yarding. The cost/revenue ratio was also adversely affected on Plots 1 and 4, because the crew was somewhat larger than necessary.

Energy Use and Yield Analysis

In table 12, we compared by plot the energy in the diesel fuel used to the potential energy that could be recovered from the wood. British thermal units (Btus) were used for comparison, and all the wood product weights were converted to oven-dry weights for uniform analysis. The Btu values for wood are the theoretical maximum potential higher heating values, and do not reflect the lower recovery that will result by burning wood in a boiler plant. Factors that contribute to lower Btu content include moisture content of the wood, incomplete combustion, and heat radiation to the atmosphere. In this analysis the following assumptions are used and their sources given.

1. One gallon of diesel fuel contains 138,000 Btus. (Department of Energy Approved Conversion Factors for Montana, Department of Natural Resources and Conservation, Helena, Montana.)
2. One 2,400-pound bone-dry unit of hogfuel equals a one and one-half 200-cubic-foot unit of hogfuel. (Champion International Corporation, Milltown, Montana.)
3. One 2,400-pound bone-dry unit of hogfuel is equivalent to 86.6 cubic feet of solid wood. (Champion International Corporation, Milltown, Montana.)
4. The maximum potential heat value for ponderosa pine is 9,100 Btus per oven-dry pound or 218,000 Btus per 86.6 cubic feet of solid wood. For lodgepole pine the values are 8,600 Btus and 206,000 Btus respectively. (Hartman,

D.A., W.A. Atkinson, B.S. Bryant and R.O. Woodfin. 1981. Conversion Factors for the Pacific Northwest Forest Industry, p. 100. Institute of Forest Resources, College of Forest Resources, University of Washington, Seattle.)

5. The maximum potential heat value for western larch is 9,100 Btus per oven-dry pound. (USDA, Forest Service, Intermountain Forest and Range Experiment Station, Missoula, MT.)

Table 12. Comparison of Energy Use and Potential Yield by Plot

Plot #	Total Btus Used	Potential Btu Yield	Difference (Yield-Use)
1	48,422,820	2,766,525,600	2,718,102,780
2	13,884,180	758,940,000	745,055,820
3	5,892,600	312,748,800	306,856,200
4	15,810,660	1,448,386,000	1,432,575,340
4a	5,016,300	671,560,000	666,543,700
5	12,793,980	851,541,600	838,747,620
6	12,828,480	3,645,582,000	3,632,753,520
6a	2,913,180	607,494,000	604,580,820
TOTALS	117,562,200	11,062,778,000	10,945,215,800

Table 12 shows that the maximum potential energy yield from all the treatment plots was over 110 times more than the actual energy used to harvest the wood and either deck it at roadside or chip it into a van for hauling. Even if we reduce the potential yield by 50 percent to reflect yields that may be expected in a normal boiler operation, recoveries exceed usage by 56 times. Hauling the material to the Champion pulp mill in Frenchtown, Montana would increase total energy consumption by

161,414,460 Btus. This is based on a 90-mile round trip, with the truck averaging 4.35 miles per gallon, and the trailer holding 10 bone-dry units of either hogfuel or pulp logs. The energy used to transport the wood is greater than that used in harvesting.

Environmental Considerations

It is generally accepted that, in most cases, cable yarding has less adverse impact on a forest stand than does ground skidding with a dozer or rubber-tired skidder. Outside of the actual yarding corridor, there is much less ground compaction with cable systems, particularly on wet or clay soils. Erosion on skid trails also becomes a problem when dozers are used on slopes exceeding 40 percent. Cable systems are ideally suited for such slopes. The only potential adverse impact from these small cable systems would be in construction of roads or trails needed to use the machines on long continuous slopes. Both the tractor winch and Bitterroot Miniyarder have a limited downhill reach--approximately 600 feet and 250 feet respectively.

The environmental consequences of the full-tree thinning and removal process are largely beneficial. Removing the wood helps protect against wildfire or insect outbreak in the residual stand. Full-tree removal increases understory vegetation, which is beneficial for wildlife or domestic livestock. A clean residual stand affords opportunities for recreation such as hunting and hiking. For many people, the aesthetic quality of a managed stand is improved when the slash is removed.

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The only potential negative environmental impact of full-tree thinning and removal on some sites could be potential depletion of the long-term soil nutrient supply. Dr. Nellie Stark of the School of Forestry, University of Montana, has studied the effects of biomass removal on soil fertility, and has concluded that for most areas this type of thinning will not

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CONCLUSIONS AND RECOMMENDATIONS

Major Findings and Recommendations

Overall, the project was successful in meeting its goals and objectives. All three machines removed full trees up to approximately 11 inches DBH with little damage to the residual stand. The machines functioned well, and with a minimum of downtime. The simplicity of operation and ease of maintenance of the machines enhance their suitability for landowners and part-time operators. The machines worked in a variety of stand types and timber sizes; therefore the production data is

accurate enough to predict production in similar operations throughout the state and region. The project was successful because it demonstrated the thinning technique to a wide audience of private landowners, small contractors, professional foresters, and other interested individuals.

Some general conclusions can also be drawn from the economic analysis presented earlier in the report. (1) Full-tree thinning and removal with these machines is not a revenue-generating operation in all cases. As with many silvicultural practices, thinning on steep terrain is costly, and must be considered as an investment in the growth potential of the stand. (2) The economic viability of these systems is dependent on tree size, crew size, value of the end product, and thinning technique. (3) These operations will not pay for themselves in small timber (less than 6 inches DBH) at the current market prices for hogfuel or pulpwood. Even with an optimum-sized crew working at full efficiency, the system would not break even in small timber unless the price of the final product rises. (4) Full-tree thinning small stems on steep slopes will require a subsidy, such as removal of commercial timber, or through increased growth in the residual stand, or increased forage production, or good recreational opportunities, or reduced risk of fire and insect damage. All of these may help offset the costs of thinning.

The Bitterroot Miniyarder is ideal for removing full trees less than 10 inches DBH in a thinning operation. The machine is safe to use, and is easy to set up, operate, and maintain. The

Miniyarder, when used with breakaway blocks and a carriage stop tieback line, will lightly thin a stand with very little damage to the residual trees. A slope of at least 17 percent on the skyline is necessary for the carriage to operate efficiently. However, on broken terrain, the intermediate support type carriage maintained the required deflection in the skyline. Because the machine has only 18 horsepower and uses small lines, yarding capacity can be seriously affected by skyline deflection on the gentler slopes. As a result, it was more efficient to yard many small turns than a few large turns. The grapple-equipped farm tractors worked well for moving the trees from the yarder to the processing area.

Although the Clearwater Yarder was more difficult to set up, and required a larger crew, it was the most productive and economically efficient machine (see table 11). This unit is best for thinning larger diameter trees, and it has sufficient power to yard the occasional overstory trees often found in thinning operations. The intermediate support carriage also worked well with the Clearwater, but it was necessary to guyline the small trees used to support the intermediate support jack and tailhold. We used the John Deere Model 440 grapple skidder as the swing machine because it more closely matched the yarding capacity of the Clearwater.

The tractor winch system worked best when the three-person crew thinned the plot in a series of narrow strips that ran parallel to the road. Each strip was approximately one tree length wide. After the crew thinned and winched the trees from

the first strip to settings along the road, the winch was removed from the tractor and replaced with the grapple. Then one person skidded the bunches to a central landing while the remaining crew members thinned the second strip. After the bunches from the first strip were moved to the landing, the grapple was replaced with the winch and the process was repeated on the remaining strips. The tractor winch is most efficient when the yarding distance is less than 150 feet. At greater distances, the direct line of pull is restricted by the short height of the tractor fairlead, and as a result, control over the incoming turn is decreased significantly. Uphill yarding affords more control than downhill yarding because gravity will hold and align the bunches on the fall line of the slope. Control of the drag is critical in thinning operations where damage to the residual stand should be minimized.

The following recommendations should increase the efficiency and economical viability of these machines for yarding full trees in a thinning operation.

1. The crew size should be kept to a minimum. Labor costs often will determine the economic feasibility of thinning with these systems.
2. These systems should be used in stands where the average tree sizes are in the six- to ten-inch DBH range. Trees of these sizes would potentially produce a higher value end product, such as posts, poles, and houselogs. Trees of this size would also ensure that supports for the machine guylines, tailhold, and intermediate support jack would be readily available.

3. This small machinery is best suited to stands where minimal development is required for roads and landings.
4. The type and steepness of slope are important to the efficient operation of any live skyline system. We believe that with the Miniyarder the skyline should be at least 20 feet from the ground at its lowest point when it is pulled tight without a load. This distance should be sufficient to maintain the proper lead on the logs while yarding them to the landing.
5. The tractor winch system is more efficient when yarding uphill because it is easier for the crew to pull the cable and rigging downhill.
6. The Miniyarder is best for situations where the timber is small and the residual tree spacing is relatively dense. By contrast, the Clearwater is more efficient when the average tree size in the stand is large and more material is removed.

Additional Work and Development Needed

Minor modifications in the equipment were made as the project progressed, particularly in the rigging of the tailhold and intermediate support jack. When the woods crew was working 500 to 600 feet downhill, and not in line of sight with the yarder operator, the small, voice-actuated FM radios were not powerful enough for reliable communication.

Three tests that were included in the initial proposal were not done. First, there was no downhill yarding with the Clearwater, because of difficulty in rigging the yarder and the

lack of a suitable demonstration site near the Lubrecht headquarters. We substituted instead a direct comparison of the Clearwater and Miniyarder on Treatment Plot 6. We felt that this test would be beneficial because most yarding is done uphill, and it would answer questions about the productivity of the two machines under the same conditions. Second, a "hands-on" training session for interested landowners, contractors, and foresters was to be held in the summer and fall of 1985. However, the severe fire season during June and July, followed by heavy rains in August and September, disrupted our schedule and precluded this training. Despite this, a number of individuals did operate some of the machinery on an informal basis, and planned demonstrations in the state during the fall of 1986 will enable many people to view the systems and operate the machinery. Third, the tractor winch was to be used to thin a stand of larger diameter trees, but when funding for the project was reduced, we had to drop this part of the program. This information is needed, and we will attempt to establish a small test plot for it on Lubrecht during the summer of 1986.

Required Permits and Authorizations

The only special permits needed to conduct the project were timber sale agreements with the State of Montana and Champion International Corporation for the plots that were established on their land. A landowner who wanted to conduct similar operations would need the usual State of Montana permits pertaining to hauling wood products, such as the Gross Vehicular Weight Permit.

GRANT ADMINISTRATION

Despite delays in gaining approval for a revised budget from DNRC, we were satisfied with the administration of the grant, and with Howard Haines, our contact person in the Energy Division. It was helpful to deal with the same person throughout the entire program, because he was familiar not only with the intent of the project, but also with the specific scope of work statements for each milestone. This allowed flexibility in administration that would not have been possible otherwise. Although the project actually began in October 1983, the final contract was not signed until February 1984. However, this was not a problem, because we could do initial planning and make necessary equipment purchases during the fall and winter months. It could have been a problem if we had wanted to begin our field work in the fall.

Work Schedules

The original contract was to extend until June 30, 1985. However, in June 1984, we were informed that the budget would have to be reduced because coal tax revenues were 20 percent below projected levels. Because DNRC would not know the exact amount of the reduction until November 1984, we were given the option to terminate the project and reapply during the next grant period. We were well into our field work for the 1984 season, so we decided to reduce the scope of work to be commensurate with anticipated revenues. Also, the contract

administrator was able to secure some additional funding from other sources that reduced the size of the anticipated cutback. On October 30, 1984, we sent DNRC our proposed revisions, which reflected the anticipated funding, but we did not receive a final signed amendment to the original contract until early June 1985. In the interim, we worked under the assumption that our proposed revisions would be acceptable. Once again, communication with Mr. Haines enabled us to proceed with the work without losing valuable field time. As a result of this delay, the project was extended until October 30, 1985. We assume that these delays were not unique to this project, but that many of the other programs dependent on coal tax revenues were also affected.

On October 11, 1985, we requested and received permission to extend the contract until May 30, 1986. The extension was necessary to complete road maintenance, landing cleanup, and to erect signs on some of the treatment plots. We also had to process field data from the treatment plots that were completed in September. Work on parts of Treatment Plot 5 and all of Treatment Plot 6 were delayed by the extremely hot, dry weather and by the high fire hazard in June and July, followed by the record-setting rainfall in August and September. If we had been operating under the original contract, it would have been impossible to complete the field work during 1985. The final report was prepared during November and December 1985, and was submitted to DNRC in January 1986.

Budget

Although the grant was reduced from $92,000 to $75,962, the project was successfully completed by reducing the size of the treatment plots. In addition, excellent cooperation from the Montana Forest and Conservation Experiment Station, the Missoula Equipment Development Center, and Potter Logging helped the project meet its goals and objectives. In addition to the funds administered by DNRC, the following organizations donated either directly or in the form of in-kind contributions of labor and machinery.

Montana Forest and Conservation Experiment Station	$24,736.23
USDA Forest Service, Equipment Development Center, Missoula	2,873.44
USDA Forest Service, Intermountain Forest and Range Experiment Station, Missoula	1,278.00
TOTAL	$28,887.67

Although Potter Logging did not file an official In-kind Contribution form, their crew donated approximately $650.00 worth of labor. Revenue from the products recovered on the treatment units offset part of the processing and hauling costs.

Table 13. Funds Budgeted and Expended by Category and Milestone Number

Milestone Number	Salaries/ Benefits	Supplies	Communi- cation	Contracted Services	Travel	Equipment	Indirect Costs	Total
[1]Budgeted	—	2,100	—	1,800	—	2,200	—	6,100
Expended	—	1,550	—	1,800	599.80	2,150	—	6,100
[3]Budgeted	5,635	500	—	6,220	—	—	1,690	14,045
Expended	5,516.61	563.91	—	6,129.25	—	—	1,654.99	13,864.77
[4]Budgeted	7,406	500	—	—	—	—	2,222	10,128
Expended	7,524.38	346.61	—	—	—	—	2,257.01	10,128
[5]Budgeted	—	450	—	5,420	—	—	—	5,780
Expended	—	427.19	—	5,442.81	—	—	—	5,780
[6]Budgeted	5,671	500	—	—	—	—	1,701	7,872
Expended	5,794.45	376.55	—	—	—	—	1,701	7,872
[8]Budgeted	5,900	250	—	3,765	—	—	1,770	11,685
Expended	6,489.37	188.44	—	3,237.19	—	—	1,770	11,685
[10]Budgeted	4,600	810	—	—	—	—	1,380	6,790
Expended	4,659.40	74.50	—	—	—	—	1,380	6,113.90
[11]Budgeted	5,894	1,500	1,810	—	2,500	—	1,768	13,472
Expended	5,408.10	5,988.02	274.46	595.75	244	—	1,622.43	14,132.76

GRAND TOTALS

Budgeted	35,106	6,610	1,810	17,205	2,500	2,200	10,531	75,962
Expended	35,392.32	9,515.42	274.46	17,205	843.80	2,150	10,385.43	75,766.43

APPENDIX A

MILESTONE REPORT 1

EQUIPMENT PROCUREMENT

MILESTONE 1 - EQUIPMENT PROCUREMENT

Objectives

The objective of Milestone 1 is to determine the type of low-cost equipment necessary to remove small timber from steep slopes. This objective is the necessary first step in fulfilling the purpose of the overall study which is to investigate, demonstrate, analyze and determine feasible low-cost methods to thin small timber from steep slopes for fuel wood and other products. The project will be conducted on two different slope categories. Slopes in the first class are short pitches -rarely exceeding 200 feet - which occur between benchland in foothill terrain. The second type are the long, continuous mountainside gradients. From previous experimental work we concluded that a single machine would not be equally efficient for both slope categories. We therefore examined different equipment for the two slope classes.

Criteria for Equipment Selection

The equipment and systems developed in this study will be of interest primarily to the private, non-industrial landowners, who not only want to improve their timberland but also want to recover saleable products to help offset operational costs. However industrial landowners and public agencies could also use these methods in thinning operations to recover the wood for potential energy uses. Some landowners or landmanagers may merely wish to remove the material from the stand to realize other benefits of full tree thinning; for example the reduced potential of wildfire or insect outbreak, reduced slash disposal costs, enhanced forage value of the area, or ease of re-entry for future harvesting. Because of the type of potential users and their objectives, the operational speed and maximum production rates of machinery were not the primary considerations. The following factors, in our opinion, were more important:

1. Low inital cost
2. Low operational cost
3. Ease of operation
4. Versatility
5. Portability

The low initial cost of the equipment is important, because in most cases, the landowner will only use it part-time. Likewise because total production will be relatively small, operational costs must be low. The machinery should also be easy to use and maintain, because it will not be operated by professional woods workers. The machine should be able to work on a wide range of slopes and timber types so that many different landowners can use the equipment. If the machine is reasonably portable, a landowner can move it easily from thinning area to thinning area. In addition the machine could be more conveniently used cooperatively by a group of landowners.

With these criteria as guidelines, we considered a range of machinery for the two types of slopes.

Equipment Alternatives

Because this equipment should be able to work on slopes in excess of 50%, crawler tractors or other direct ground skidding methods were not considered feasible alternatives. Therefore we considered either winches or cable yarding systems as the type equipment suitable for steep slope thinning.

Two basic types of small winches were evaluated for use on the short, benchland slopes. The first type was a KOLPE Radio-Tir winch developed in Sweden. This six horsepower machine weighs 330 pounds, holds up to 150 yards of 1/4 inch cable and has a unique drive system that produces 1700 pounds of line pull. In addition it is radio controlled so that one person can operate the machine effectively. Because the entire unit is mounted on a steel sled, it can pull itself around the woods or into a truck or trailer. In a previous cooperative study with the U.S. Forest Service, we tested the winch in steep slope thinning operations and found that it performed satisfactorily pulling small diameter trees. It is light weight, self-powered, trouble free and can be operated effectively by one person. However, it also has a relatively high initial cost ($8,000 plus) and limited power for full trees in the seven to eight inch diameter range.

We also investigated a winch system for a conventional farm tractor. The winch was developed in Finland for farmers, woodlot owners and small contractors. This single drum winch is mounted on a frame attached to the three point hitch and driven by the power take-off shaft of the tractor. The clutch is a dry friction type controlled by the operator via a rope. The winch frame has either a beam with adjustable stabilizer legs or a blade which not only acts as a stabilizer but also can be used for stacking logs or moving earth. These systems are available in a range of sizes that will fit tractors from 20 to 100 horsepower and have corresponding cable sizes from 1/4 to 9/16ths of an inch. The two major brands distributed in the U. S. are Farmi and Pacific. These winches not only have the pulling capacity for a range of tree sizes, but they also have a relatively low initial cost (approximatley $1,200 to $5,000.) The major disadvantage is that this winch must be powered by a tractor and therefore is not a stand-alone unit. In addition, the winches have a limited line capacity of about 250 feet with the larger diameter cable, and with the added power the cable will bind occassionally on the spool.

For thinning on the long, continuous mountainside slopes for distances up to 800 feet, we considered a number of small cable yarding systems. The winch systems are not suitable because of limited cable capacity, slow infeed rates, and lack of an automatic

outhaul feature. The Europeans and Scandanavians have developed a number of small cable systems and a few of these are operating in this country. The only system readily available in the western United States is the Koller Yarder. The Model K300 is suitable for thinning and small wood harvesting operations. It can be purchased either as a self contained trailer mounted unit or as a tower and drum set that is powered by a minimum 40 horsepower farm tractor. Either unit is basically a two drum standing skyline system for uphill yarding. It is equipped with a 5/8th inch skyline and a 3/8th inch mainline and is capable of yarding a 1 ton load from distances of approximately 1000 feet. The attached specifications describe the unit in more detail. Although we did not personally test or use this machine, we did view a demonstration sponsored by the Forest Service. The major advantage of this unit is that it is a proven machine that has the capacity to yard small commercial sized sawlogs. However the yarder, fully rigged with a carriage, ranges in price from $23,000 for the tractor mounted model to over $32,000 for the self-contained trailer unit. In addition, the nearest dealer is in Oregon, so it may prove difficult to obtain parts or service.

An alternative to the Koller is the Clearwater Yarder which was developed in 1977, by the Missoula Equipment Development Center of the Forest Service. This self-contained unit can be constructed in small shops and is designed to mount on either a flatbed truck or trailer. Unlike the Koller which is a mechanically driven, the Clearwater is powered by a hydrostatic transmission with electric over hydraulic controls. The Clearwater can also be rigged in a variety of configurations for either uphill or downhill yarding, although the downhill mode has been the most common to date. The line sizes, speeds and payload capacities are similiar to the Koller. Two manufactures, one located in Idaho and the other in Montana, have built commercial versions of this unit which cost approximately $50,000 to $60,000 fully rigged. The attached Christy Small Wood Yarder specification sheet is an example of this type unit. The advantages and disadvantages of these units are similiar to those of the Koller. However, they are very suitable for the small logging contractor. We had the opportunity to test this unit briefly and it performed to our expectations and requirements.

The last type of small, cable yarder that we tested is the Bitterroot Miniyarder, which was also developed by the Missoula Equipment Development Center. The Miniyarder is a lightweight, compact, two-drum skyline yarder, designed to remove light slash, thinnings and small stems. At 1,600 pounds fully rigged, the Bitterroot Miniyarder easily mounts in a 3/4 ton truck or on a small trailer. It is powered by an 18 horsepower Briggs and Stratton twin cylinder, air cooled engine. It is equipped with hydrostatic drive which enables the operator to use maximum engine horsepower by balancing line speed with line pull. The most popular cable sizes are 3/8th inch for the skyline and 1/4 inch for the mainline. With these size lines, the drums will hold approximately 650 feet of

skyline and 800 feet of mainline. The unit is used most commonly in a live skyline configuration with a Christy carriage. Parts and materials for a fully rigged Bitterroot Miniyarder cost about $7,500 and can be shop built using many commercial parts which are readily available. Prices for commercially built complete units have ranged from $14,500 to $18,000, exclusive of carrier. The major advantages of the Miniyarder are its low initial cost, low operating expense, ease of operation and portability. Because of low horsepower and small line sizes, the major limitation of the Miniyarder is its small payload capacity. As was indicated in a test conducted by the Washington Department of Natural Resources, Miniyarder capacity is also very sensitive to deflection angle. Small deflection angles can significantly reduce expected payloads.

Equipment Selected for the Project

We selected the Pacific Model 500 S winch to yard the short slopes under 200 feet long for a number of reasons. First, it demonstrated a system that had a wide variety of models commercially available so that interested landowners could choose a size to fit their specific requirements. Second, the initial cost of our project winch was $2,150, which was within the alloted budget. The retail cost of this winch is approximately $2,700, - substantially less than the $8,000 plus for the Kolpe Radio-Tir Model 740. Third, this winch has the versatility and pulling capacity for those landowners who choose to remove commercial timber in conjunction with precommercial thinning. Fourth, a Misssoula dealer sells this winch, so accessory parts and service should be easy to obtain. Fifth, we had the opportunity to use this winch on a trial basis in another project and were impressed with its performance. We felt that these advantages outweighed the fact that a tractor is required to power the winch. In our opinion, ranchers and farmers would have a tractor available to use with the winch, as would most other rural landowerns interested in thinning. Because the Pacific brand is manufactured in the northwest, we purchased it rather than the Farmi. However from all indications, the two brands are almost indentical. By purchasing the winch rather than leasing it, we will be able to make some modifications to the unit, as will be described in a subsequent Milestone Report.

We chose the Bitterroot Miniyarder as the primary cable yarding system to test and demonstrate on the longer slopes. Once again this machine more closely met all our criteria. We simply did not have the funds available in this project to lease or purchase a Koller Yarder or similar commercially available machine. We have an agreement with the Forest Service to use a Miniyarder for the duration of the project and to make such modifications to the unit as are necessary for our work. In addition, the low initial cost of the yarder, either for just the materials or ready built, should appeal to the private landowner who wants to thin on mountainous terrain. Second, as we demonstrated in our previous

trials, the machine is easy to operate and maintain. A person can run the machine with some proficency after just a few hours of operation. Third, the operational and maintenance costs are very low, and the parts are readily available from most hydraulic or machinery supply outlets. Fourth, the machine is very portable, particularly when mounted on a trailer. It can be moved easily on the road with a 3/4 ton pickup truck and through the woods with a farm tractor. It is very suitable for thinning small areas of ground with a minimum of moving and set-up time. The major disadvantage of the Miniyarder compared to one of the larger machines is its inability to consistently yard the small commercially-sized full trees. However we have found in our trials that proper felling techniques will minimize problems and increase payload capacities. Also it was occassionally necessary to buck the tree into one or more pieces to properly match load size with machine capability. In our opinion, the advantages of the machine outweigh the disadvantages.

We propose to use the Clearwater Yarder on one of the areas to yard trees both uphill and downhill. Although this will be a limited trial and demonstration, we hope to gather enough information to compare production costs between the Miniyarder and the Clearwater. The Forest Service will provide both the machine and operator for this portion of the study. If the opportunity arises during the course of the study, we will test one of the commercially built larger yarders.

Equipment Modification

Based on our trials with both the Pacfic winch and the Miniyarder, we have either already made or plan to make some modifications to the units. These modifications do not appear on the specification sheets or plans which accompany this report, but they will be described in detail in the Milestone 2 report.

Auxilliary Equipment

One additional piece of equipment which is an integral part of both the short and long slope systems has not yet been described. This is a farm tractor equipped with a shop built grapple which attaches to the three point hitch. The role of this unit in the system will be described in the second Milestone report. However a brief description of the unit together with a data sheet and construction specifications will be included in this report.

The skidding grapple was first designed by a neighboring rancher, Mr. Bill Potter of the By The Way Ranch, over 12 years ago. He developed this equipment as an alternative to using a crawler tractor and chokers for skidding logs and forest thinnings on gentle terrain. Over the course of 8 years, he developed and

built 4 different models. Then in 1981, the Missoula Equipment Development Center used his basic design to develop the shop drawings and specifications which are attached. Potter has used the various designs on a wide range of farm tractors to skid over two million board feet of small sawlogs and thousands of bunches of small tree thinnings. Our previous studies have demonstrated that a conventional farm tractor, modified slightly for woods use and equipped with the grapple, is an economical and efficient alternative to a commercial skidder when used on gentle terrain with the appropriate sized loads.

The farm tractor modifications include extra guards for the radiator, a cover for the power take off shaft, a belly or skid pan, and tire valve stem protection. We replace the bucket on the front end loader with a set of short teeth for pushing material out of the skidways. The grapple, which is equipped with a heeling bar, is then attached to the three point hitch. The top arm of the hitch is replaced with a hydraulic cylinder which enables the operator to tilt the grapple forward and backward. In addition he can lift the grapple up and down with the standard hitch mechanism. The grapple teeth are closed with a set of hydraulic cylinders. These hydraulic functions require one additional bank of hydraulic valves on the rear of the tractor - a standard option on most farm tractors. A tractor so equipped can not only skid trees directly from the woods,but can also forward the bunches of stems from the yarder or tractor winch to a landing for processing. This use will be described in the following report.

APPENDIX B

MILESTONE REPORT 2

SYSTEM TESTING

MILESTONE 2 - SYSTEM TESTING

INTRODUCTION

The purpose of Milestone # 2 was to field test both the tractor winch and the Bitterroot Miniyarder to develop techniques which would be used on the demonstration plot treatments. We wanted to become familiar with the equipment and at the same time test a variety of rigging and yarding techniques and associated crew configurations to ensure that the methods used on the demonstration areas were the most practical and feasible. During the testing period we also modified the equipment to make it more applicable and efficient for our operation. Finally we were able to test the value of accessory equipment such as breakaway blocks, tree pads and skyline tieback cables.

TECHNIQUES INVESTIGATED

Winch:

We tested the tractor winch in two general system configurations to yard material uphill. In the first approach, the winch was used as a prebuncher to remove the material from the woods and a grapple equipped farm tractor then forwarded the bunches to a landing for processing. We located three test corridors in a ponderosa pine stand on a 35 percent slope below a bench. On two of the strips, which were approximately 200 feet long, the trees were felled and bunched in a herringbone pattern with the butts facing the corridor. The crew fell the trees concurrently with the yarding on the third strip. Four people yarded the first two corridors - two in the woods, one person operated the tractor winch and the fourth person used a grapple equipped tractor to remove the bunches to the landing. The two people in the woods used square link skidding chains to fasten the bunches to the mainline of the winch. The winch operator would then yard the bunches uphill to the tractor, raise the three point hitch to lift the front of the load off the ground and skid the bunches 40 feet up the trail to the landing. Here he would drop the load, unfasten the chains and return to the head of the corridor. One of the woods crew would be waiting to take the winch line and chains back down the hill. After setting the choker chains, the woods crew would signal the winch operator and the process would begin again. The fourth crew member forwarded the bunches from the drop point on the skid trail to the landing for sorting and processing. The procedure was essentially the same on the third corridor, except the woods crew (three people in this case) began felling the next drag as soon as the previous one began moving uphill.

Two additional corridors were established to test a second system in which the winching tractor skidded the bunches all the way to the landing. Once again the trees were prefelled on one corridor and felled concurrently with yarding on the second. The operating

procedure for the woods crew was similiar to that of the first three test corridors. On all areas the crew used breakaway blocks to guide the drags along the lateral corridors and into the main one leading uphill. The crew also found that the angle of the lateral trail to the main corridor should not exceed approxmiately 60 degrees, otherwise the bunches had a tendency to roll downhill as they were being winched.

Based on these trials, both systems (and either felling method) appeared to be feasible depending on crew size and distance from the corridor to the main landing. When the landing was only a few hundred feet away, the second approach was most efficient, particularly when the crew fell the trees concurrently with the yarding. The winch operator was busy continually in this case except for the brief time the woods crew spent dragging the winch line downhill. The first approach was more feasible when the crew was working with prefelled timber and the landing was over 200 feet from the top of the corridor. The woods crew did not have to wait for the tractor to return from the landing. As a general rule, winching efficiency was noticeably increased when the woods crew preset chokers. In all cases it is important that the method or combination of methods be viewed as one system from stump to landing and that all idle time be eliminated from each phase of the operation.

A number of general operating principles common to all systems soon became apparent. First, the winch had sufficient power to skid a number of full trees in the four to eight inch DBH size range. Load sizes were not limited by the power of the winch but by the ability to maneuver the drag through the stand. It was necessary to balance load size with the width and straightness of the corridor to prevent hangups and other delay time. Second, load size could be increased when lateral yarding distances were decreased. Third, because it was not practical to use nose pans or cones with this system, we could not efficiently accumulate more than one turn at a time behind the tractor. As a result, the tractor had to move each turn away from the top of the corridor before yarding the next one. On long skids, we found that it was much more effective to let the grapple equipped tractor build capacity loads from single winch turns. Finally, the major disadvantage of the winch system is the need to hand pull the cable out to the bunches. Under most normal operating circumstances this will limit the winch system to about a 250 foot total yarding distance.

Miniyarder:

We tested the Bitterroot Miniyarder in both thinning and clearcut operations. In the thinning trials we prefell the trees in some cases and in others, the trees were fell concurrently with the yarding. However the operational procedure was similiar in both instances. First the skyline corridor was located and the trees were

felled. Where prefelling was tested, the trees were felled and bunched in secondary corridors located in a herringbone pattern at an approximate 45 degree angle from the skyline corridor. A three to four person crew did the felling and bunching. The yarding crew consisted of four people, two in the woods, one operating the yarder and the fourth using a grapple equipped farm tractor to move the bunches from the yarder to the landing. The yarder was rigged in a live skyline configuration so the operator unhooked the loads at the machine. The two person woods crew set chokers, positioned breakaway blocks and set the carriage stop. After two to three turns had accumulated at the yarder, the tractor operator would skid the entire bunch to the landing. In those instances when felling and yarding occurred simultaneously, one extra person was added to the woods crew. This crew member was responsible for directionally falling the trees and selecting the lateral corridors. The second crew member assisted with the directional felling and preset chokers. The third person chased the mainline, set breakaway blocks and hooked turns. The remaining crew members' duties were essentially unchanged from the first system. For a short time we tried using just one person in the woods where the trees were prefelled and bunched. This method was effective only when the lateral yarding distance was less than a tree length and the breakaway blocks were not used. In all the other circumstances we felt that the yarder was idle for an unacceptable amount of time. It was also often difficult for one person to free the occasional hangups along the secondary corridors.

The miniyarder was also used in a cooperative trial with a post and pole contractor who was clearcutting a small stand of lodgepole pine. His three person crew used the trailer mounted miniyarder both with and without a swing machine. The purpose of not using a swing machine was to avoid, if possible, the extra cost of the skidder and operator. The plan was to accumulate all the trees from one corridor under the yarder, then move the machine to the next setting and so on down the road. A self-loading log truck would then follow behind the yarder picking up the decks. Each morning the crew felled, limbed and topped the trees to be yarded that day. For the remaining time one person operated the yarder and unhooked loads and the other two crew members set chokers. Although this was an efficient use of the three person crew, the system proved unsatisfactory for two reasons. First the crew had difficulty decking the logs under the miniyarder. They were operating on a 40 percent sideslope and after the deck reached a certain size, the newly added top logs would slide off the pile. Because the logs were all yarded butt first, the problem became more acute as the pile got larger. Second, loading also proved difficult because the self loader could not always reach and swing the logs in one operation. Often when the operator would set the log down to reposition the loader grapple, the log would slide downhill. Although this approach may be suitable when either a landing existed or was constructed under the yarder, it was not feasible in this case.

To overcome the difficulties associated with stockpiling the trees under the yarder, the contractor added a small cable skidder to the operation. After three to four turns accumulated in front of the yarder, the skidder operator chokered these stems and forwarded them to a landing on the road where they were decked for future hauling. Although a grapple equipped forwarder would have been more efficient, the cable skidder significantly increased the production of the crew. The duties of the basic three person crew remained the same when the skidder was added to the system, however they were able to cut wider corridors and reduce the number of settings for the miniyarder.

The thinning and clearcut trials revealed some important common operating principles for the miniyarder. First, as with the tractor winch, it is critical to consider the entire operation from stump to landing as one system and all phases of the system must operate together efficiently. Second, either prefelling the trees or concurrent felling/yarding appear to work equally well. The choice of which technique to use will depend on a number of factors such as crew size, tree size and intensity of harvest. Third, hangups in the inhaul phase of the yarding were the biggest cause of operational delay. As a rule it was more efficient to yard smaller turns at a faster rate rather than yarding overly large turns which had a tendency to hang up. Fourth, to yard thinnings with a minimum of damage to the residual stand, the breakaway blocks and skyline tieback cable were essential accessories. Fifth, the grapple farm tractor complements the miniyarder very nicely. It is not only an inexpensive swing machine but also the tractor works well for moving the trailer-mounted miniyarder between settings. Finally, the slope of the skyline must be at least 15 percent for the gravity outhaul carriage to operate properly.

CREW SIZES

As indicated in the previous section, we used a variety of crew sizes in the different trials with the tractor winch and miniyarder. As a result of the testing it does not appear that one crew size will be necessarily optimum for all operations. Different crew sizes can be equally effective depending on timber size, time and method of tree felling, method of harvest or thinning intensity and type and degree of processing at the landing. However, from these tests we were able to estimate which crew configuration and size would be most applicable to the various demonstration plots.

We will use a basic three person crew for the tractor winch treatment areas. In the felling and bunching phase one person will saw and two people will stack and bunch the trees. After the felling and bunching is completed, the same crew will yard the bunches from the woods. One crew member will operate the winch and tractor and the remaining two people will drag winch cable, choker the bunches and set breakaway blocks where needed. The tractor

operator will skid the bunches either to an intermediate point along the skidway or to the landing. As space limitations dictate, the tractor operator will replace the winch with the grapple and shingle stack the bunches for future processing.

For the majority of the thinning treatments with the miniyarder we will use a three person felling crew, one sawyer and two stackers, to fell and bunch the trees prior to yarding. The yarding crew will normally consist of four people, one tractor operator swinging bunches from the yarder, a yarder operator and chaser, and two people setting chokers and breakaway blocks in the woods. On one of the thinning units we will fell the trees concurrently with the yarding and in this case an extra person will be added to the woods crew to assist with the felling. On the lodgepole pine clearcut unit both prefelling and concurrent felling/yarding will be used. The felling and yarding crew for the respective methods will be similiar to the thinning treatments.

We plan to full tree chip the material from most of the units for hogfuel. The yarding crew will do this work in a separate operation. However on the lodgepole pine thinning unit, we will cut poles from the larger trees so an additional crew member will be required to limb, buck, and deck the poles. We plan to limb and debark some of the trees from the clearcut and process them for pulp quality chips. If this opportunity materializes, we will add one more crew member to assist with this extra processing. In all cases, production rates will be tallied separately for each phase of the operation.

EQUIPMENT LIST

Two basic pieces of equipment, the tractor winch and Bitterroot Miniyarder, will be used on the demonstration treatment plots. If project funding permits, we will yard one area with the Clearwater Yarder to contrast the production rates of this larger machine with those of the miniyarder. In addition, a grapple equipped farm tractor will be used on all the units to either forward bunches from the yarder or to stockpile bunches on the landing. These units and the criteria for their selection have been described in detail in the Milestone # 1 Report. However it would be appropriate to describe briefly modifications that we have either made or plan to make on the major equipment as a result of our initial trials. These changes do not appear on the specification sheets or plans which were included in the first Milestone Report.

We found that the connectors on the Pacific Winch which attached to the lower arms of the three point hitch were not spaced far enough apart to fit the Model 2940 John Deere farm tractor. We added another set of connectors to the winch so that it will now fit a wider range of tractor models. We are also contemplating the addition of a radio control mechanism to the tractor winch. We have

considered actuating the winch clutch with a radio controlled hydraulic valve and engineers from the Missoula Equipment Development Center believe that this approach is feasible. If this modification proves successful, the present three person crew could be reduced by one member, or even one person could operate the system efficiently.

Since our first trials with the miniyarder, we have made a number of modifications both in the machine itself and in the carrier. We changed the single tower block which had a sheave each for the skyline and mainline to separate blocks for each line. The double blocks reduced wear on the shoulders of the pulleys. Originally the tower guylines were fastened around stumps or trees with a chain, ratchet and cable clamp. To minimize damage when live tree were used as anchors, we replaced the chain and ratchet with large nylon straps. New, easier operating clutch and brake levers were also added to the control panel. We have used a trailer mounted miniyarder in all our trials and have found the trailer to be a very versatile carrier for the yarder. The major modification to the trailer has been the addition of a rotating turn table mount for the yarder so that we can work either from the back or side of the trailer. With this capability we can more easily position the yarder and move it quickly between settings. The trailer is equipped with a dual hitch so that a tractor can move the unit around the woods and a truck can pull the trailer at highway speeds. The Missoula Equipment Development Center is building a custom trailer to replace the modified army surplus unit currently in use.

There are a number of items of accessory equipment which we feel are essential to the effective operation of the miniyarder. First, for safety and efficiency, the yarder operator must be able to communicate with the woods crew. We have successfully used a pair of small, FM, voice actuated transceivers for this purpose. The units are inexpensive ($65 each) and very portable, operate with rechargeable "AA" batteries, and have an effective range of up to 0.5 miles. These units allow both the operator and woods crew to have "hands free" voice communication to minimize lost time from hangups, slipped chokers and so forth. The second group of accessories includes items that we had used previously with the Kolpe Radio-Tir skidding winch. The most important of these are the breakaway blocks which are open-faced sheaves with a spring loaded arm located over one edge of the pulley. The block fastens to the tree with a nylon strap. The block self releases when the butt rigging on the mainline trips the arm and the turn changes direction. We used these units primarily where lateral corridors joined the main skyline corridor. The blocks enabled us to use narrow corridors with few hangups and a minimum of damage to the residual stand. We also used nylon pads on the thin barked lodgepole pine to prevent damage from the nylon straps. The last major accessory item was a 30 foot choker with a bell on either end and a sliding keeper. We put a second keeper on the skyline at the carriage stop. We could then fasten the choker at the skyline stop

and wrap the other end around a stump or tree to minimize lateral movement of the skyline during lateral yarding. This device also enabled us to use narrow corridors and to minimize barking of trees along the main skyline corridor.

INFORMATION TRANSFER

During the course of the trials with the miniyarder and tractor winch we conducted a number of formal tours and demonstrations.

Group	Number of Participants
Public Field Day	46
Forestry Alumni Tour	27
Northwest Science Association	17
Geraldine High School Students	11
Dean's Advisory Council	19
Association of Western Forestry Clubs	9
Sauerkraut Creek Demonstration	32

A number of individual landowners, loggers and other contractors also visited the sites on an informal basis. In addition, two newspaper articles were written about the Sauerkraut Creek operation - one by the weekly newspaper in Lincoln and the other by the Helena Independant Record, a copy of which is enclosed. The Log, an industry trade magazine, also did an article about our cooperative small tree harvesting and utilization work here at Lubrecht. The author of this article witnessed some of the trial work with the tractor winch and a copy of his article is enclosed for your information.

APPENDIX C

MILESTONE REPORT 3

TREATMENT PLOT 1

MILESTONE # 3 - DEMONSTRATION PLOT TREATMENT 1

PLOT LOCATION

Demonstration area 1 is located in portions of Sections 11 and 12, Township 13 North, Range 15 West, Montana Principal Meridian. This 50 year old stand of lodgepole pine is situated adjacent to State Highway 200 approximately one quarter mile north of the Lubrecht Forest Headquarters. The area was selected for treatment and yarding with the Bitterroot Miniyarder for a number of reasons. First, the terrain and timber were suitable for the miniyarder. The slope averaged 30% and the trees were in the four to eight inch diameter range. Second, the area was within easy walking distance of the Forestry Center for tours and demonstrations. Third, because the plot is visible to highway travelers, it will have excellent long term demonstration value. Fourth, three 0.5 acre thinning plots were established here in 1952, and this gave us an opportunity to rethin portions of each plot and study long term growth responses of the residual trees.

PLOT LAYOUT AND DESCRIPTION

The project area is approximately 1,200 feet long and 500 feet wide and contains 9.5 acres. The trees were yarded from a ridgetop which parallels the south side of the unit. Two treatments were established in the western portion of the area. One plot was thinned to a residual spacing of 10 feet (440 trees per acre) and the second to a 14 foot spacing (220 trees per acre.) In addition a third plot of 0.5 acres was left unthinned as a control to compare growth with that of the thinned plots. The remainder of the area, which included the old thinning plots, was thinned to an average spacing of 12 feet. The three original thinning plots were thinned to a spacing of 6.5 feet, 8 feet and 9.5 feet respectively. We thinned half of each plot and left the remaining portion at the equivalent to a four inch d.b.h. tree, 25 feet tall. Although the average tree removed on this plot was slightly larger in diameter than it's counter part on Plot 2, the average height of the trees was shorter, which resulted in a lower cubic foot volume per piece removed.

Felling and Bunching;

We kept separate hourly production figures for both the two and three person thinning crews. The two person crew averaged 58 trees per crew hour or approximately 29 trees per crew member hour. However, the three person crew averaged only 55 stems per hour or 19 stems per crew member hour. We attribute two main reasons for this difference. First, the steepness of the plot and the size of

PRE-THINNING STAND TABLE

(Values are listed on a per acre basis)

DBH Class	Number of Trees	Basal Area in Sq. Ft.	Total Stem Vol. in Cubic Feet	Total Stem Vol. in Cubic Meters
2	17	1	5	.14
3	80	4	62	1.75
4	117	11	202	5.72
5	233	32	672	19.02
6	280	56	1251	35.41
7	80	20	480	13.58
8	20	7	156	4.41
TOTALS	827	131	2828	80.03

The totals listed in the above table represent the average value of that parameter on a per acre basis for the entire stand. The average piece size is obtained by dividing the total stem volume in cubic feet by the total number of stems per acre. The average tree in the stand prior to thinning contained 3.42 cubic feet or 0.097 cubic meters.

PLOT TREATMENT

Although two different approaches were used in the thinning of this area, both systems used the same sized crew and similar equipment. The trees were all hand felled and bunched into piles that matched the yarder capacity. The trees were felled either downhill or in a herringbone pattern with the butts facing the yarding corridor. We used the Bitterroot Miniyarder to yard the trees uphill and a grapple-equipped farm tractor moved the bunches to the landing, where the large trees were limbed and bucked into poles. The tops of the large trees and the small trees were processed by a portable full tree chipper. We used a basic crew of five people for a number of reasons. First, the long term research and demonstration nature of the area required that special care be taken to minimize damage to the residual stand. Second, the location of the permanent growth plots limited the location of the skyline corridors and resulted in lateral yarding distances that often exceeded 100 feet. Also in many instances, the skyline corridors were only six to eight feet wide. Third, because of limited landing space, the yarding and

processing steps often occurred simultaneously. Finally, we hosted a number of tours and demonstrations and to conduct these most efficiently, it is necessary to have a larger crew than is normally required for a purely operational situation.

The two approaches used in the thinning differed primarily in the felling and yarding phases of the operation. On one 3.5 acre portion of the area, the crew prefelled the majority of the stems prior to yarding. The trees were felled in a herringbone pattern to predetermined skyline corridor locations. One person fell the trees and the other four crew members stacked the stems into bunches for yarding. In previous thinning work on gentle terrain we have used one faller and two stackers. We thought that the two extra people would be necessary to move and bunch the trees on the steeper terrain. However production rates indicate that this system was not as efficient as the method used on the remaining area, where the felling/bunching and yarding were done concurrently.

The same basic yarding system was used on the entire study area. The yarder crew consisted of four people, three in the woods and one operator at the landing. The yarder operator, who also unhooked the loads, used a small, voice actuated, fm radio to communicate with the woods crew. The duties of the woods crew were extensive. On that portion of the area where most of the trees were prefelled, additional trees were removed at the time of yarding to achieve the desired spacing. One person fell the additional trees and located lateral yarding corridors. The second person assisted the faller where necessary, set breakaway blocks and preset chokers. The third crew member also had a two-way radio and was responsible for moving the carriage stop, setting the stop tieback cable and attaching tree protection shields as required. The duties of the individual crew members remained essentially the same when they fell and yarded the trees at the same time. However in this second method, they often did not preset chokers and also did not make extensive use of the tree shields.

The swing phase and processing steps also were the same for both treatment areas. The fifth crew member was primarily responsible for moving the bunches of trees from the yarder to the landing, which was located on the southern edge of the unit. He used a John Deere Model 2940 four wheel drive farm tractor equipped with the hydraulic grapple to skid the bunches. At the landing he would separate the larger trees and set them aside. He stockpiled the the small trees in a shingle stack for future chipping. The second duty of the swing man was to move the trailer mounted Miniyarder from corridor to corridor as required. The tractor had a hitch attached to the front end loader frame so the operator could move the chipper without removing the grapple. An additional crew member was added to the operation because we wanted to recover poles and corral rails from the larger trees without interfering with the normal production rates of the yarder and swing operations. This

sixth person limbed and bucked the trees into poles and used another grapple equipped tractor to deck the poles and to stockpile the tops for chipping. Of the nine van loads of material chipped from the study area, five were chipped by these two people concurrently with the yarding operation and the remainder were chipped on days when the yarder was not operating.

The table which follows is a summary of the material removed from the 8.0 acres treated on the project area. The average tree removed contained 2.8 cubic feet. The green tons removed include 229 tons of chipped material and 93 tons (approximately 3,700 cubic feet) of poles.

Item	Total Amt.	Amt. per Acre
Number of Stems	3,074	384
Volume in Cubic Feet	8,607	1,075
Volume in Cubic Meters	244	30
Green Tons	322	40

Production Rates

The tables in this section list production rates in terms of stems per hour for various phases of the operation. Two primary types of hour figures are used. The first is that time in which the crew or machine was actually operating and the second includes both operational time plus associated working time including breakdown and changing skyline corridors. These times do not reflect nonproductive time such as demonstrations, lunch breaks or record keeping. Although production rates are based on stems per hour, they can be converted to cubic feet by using a multiplier of 2.8, which is the total stem volume in cubic feet of the average sized piece removed.

Felling and Bunching:

In the first system, the five person crew fell and bunched 1,441 stems in 90.5 total working hours - an average production rate of 16 stems per crew member hour or 80 stems per crew hour. By contrast, the felling and bunching rate for a three person crew on gentle terrain has averaged 40 stems per person per hour or 120 stems per crew hour. We feel that two major factors contributed to these lower production rates. It was difficult to hand pile the larger trees on the steep terrain and there were too many crew members involved in the operation. In retrospect we feel that a three or four person crew would have been more efficient and we plan to use a smaller crew on the remaining demonstration areas.

Yarding:

As described previously, two yarding methods were used on the study area. In the first system the majority of the trees were felled and bunched prior to yarding and 27Ø additional stems were felled currently with the yarding to obtain the desired final tree spacing. The following table lists in summary form the major data from this portion of the treatment area:

Item	Amount	
Yarder crew	5	people
Total stems yarded	1,711	stems
Average yarding distance	275	feet
Total turns	626	
Average number of stems per turn	2.7	stems
Skyline corridor settings	5	
Yarder operational hours	39.25	hours
Yarder downtime (clutch and cable repair)	1.75	hours
Yarder movetime	5.3	hours
Total yarder time	46.3	hours
Total crew time	185.2	hours
Yarder fuel used	34.8	gallons
Average fuel use per hour	.89	gallons

The crew moved an average of 44 stems per hour when the yarder was running. When moving and downtime are included, the average dropped to 4Ø stems per yarder hour.

In the second system the three person woods crew fell the trees concurrently with the yarding. Therefore, the data in the next table reflects both felling and yarding times.

Item	Amount	
Felling and yarding crew	4	people
Total stems yarded	1,363	stems
Average yarding distance	310	feet
Total turns	456	
Average number of stems per turn	3.0	stems
Skyline corridor settings	2	
Yarder operational hours	30.0	hours
Yarder downtime (cable repair)	0.5	hours
Yarder movetime	2.7	hours
Total yarder time	33.2	hours
Total crew time	132.8	hours
Yarder fuel use	24.0	gallons
Average fuel use per hour	0.8	gallons

In this part of the area the crew fell and moved an average of 45 stems per hour when the yarder was running or 41 stems per hour when moving and breakdown time are included.

It is apparent from the two previous tables that the second approach was more efficient with the size crew used in this operation. The yarding production rates were essentially the same for the two systems and the second method also included felling. If production is based on stems per crew hour from stump to yarder, the rate is 6.7 stems in method 1 (including felling time) and 11.4 stems in method 2. A number of factors combined to make the second approach more efficient. First, the woods crew worked to full capacity when they fell and yarded concurrently. Second, the crew could choose leave trees based not only on silvicultural but also on operational considerations. Third, the crew left "bumper" trees in critical locations along the corridor which reduced the need for breakaway blocks and tree shields. They removed the bumper trees in the last turns yarded from the corridor.

Swing phase:

The fifth crew member moved an average of 45 stems per hour away from the yarder using the grapple equipped farm tractor. However,

the swing process only consumed from 50 to 75 percent of his time. The specific amount depended both on the location of the yarder in relation to the landing and also on the time required for the yarder to accumulate a turn. Normally two to three yarder turns would constitute one tractor turn. The tractor operator used his spare time to assist the processing person on the landing. The John Deere Model 2940 tractor used an average of 0.95 gallons of fuel per hour.

Processing:

At the landing a sixth person spent 82.5 hours processing poles from the larger trees and stockpiling the remaining material for chipping. He produced 904 poles that were an average of 4.6 inches diameter inside bark on the small end and 20.7 feet long. Each piece contained 4.16 cubic feet for a total of 3,762 cubic feet. The second tractor was used 68 hours in the processing operation.

The crew also produced 144.73 units of whole tree chips in the operation (a unit equals 200 cubic feet of chipped material.) This was equivalent to 229 green tons or nine forty-foot van loads. Chipping took an average of 2 hours and 10 minutes per van load or slightly over 5 minutes per green ton. Typically the chipping system consisted of the Morbark Model 12 Chipharvestor, a farm tractor and two operators. On those four occassions when the chipping was done separately from the yarding and processing, the crew used two tractors to feed the chipper. The chipper used an average of 5.9 gallons of fuel per hour.

TECHNICAL TRANSFER

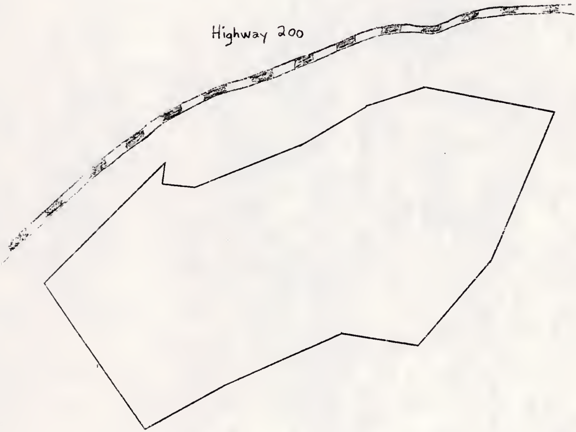
We conducted five formal demonstrations in the course of this operation.

Group	Number of Participants
American Pulpwood Association (Western Chapter)	50
National Council of Forestry Researchers	15
Forestry students	70
Tour associated with Forestry Center dedication	17
DNRC and BPA tour	10

A number of individuals also visited the project on an informal basis. Because this unit is clearly visible from Highway 200, we plan to errect an informational sign along the roadway at the conclusion of the project. Preliminary information and pictures from this project were also presented in a poster session at the Pacific Northwest Bioenergy Systems Seminar in Portland, Oregon.

LODGEPOLE THINNING AREA

MILESTONE #3



Scale: 1" = 200'

Area = 9.5 acres

APPENDIX D

MILESTONE REPORT 4

TREATMENT PLOTS 2 AND 3

MILESTONE #4 PLOTS 2 & 3

INTRODUCTION

In Milestone 4 we tested and demonstrated the use of a cable winch system mounted on a farm tractor to remove precommercial-sized thinning residue from a stand of second growth ponderosa pine. Two treatment plots were installed on short slopes. On one plot thinned material was winched uphill, decked along the road and later processed into industrial fuel wood (hog fuel.) On the second plot, thinned material was winched downhill, skidded to a cold deck and later processed into hog fuel.

PLOT LOCATION

Treatment Plots 2 and 3 are located on the Lubrecht Experimental Forest in Section 6, T.13 N., R.15 W., Principle Meridian Montana. The two plots are situated along either side of the Morrison Peak Road approximately 2.5 miles from Montana Highway 200. This area was selected for three reasons. First, with the plots located across the road from one another, we were able to yard both uphill and downhill in the same area under similar stand conditions. Second, both plots were located in stands of predominately second- growth ponderosa pine on short, moderately steep pitches that averaged thirty percent. Third, the trees were suitable in size for the winch and the stand needed precommercial thinning.

TREATMENT PLOT 2

PLOT DESCRIPTION AND LAYOUT

Treatment Plot 2 was established in a 80 year old mixed stand of ponderosa pine and Douglas fir. The area totals 3.1 acres and is on a southwest facing aspect that ranges in slope from 25 - 40 percent. The top edge of the plot runs 500 feet along the Morrison Peak Road. The bottom of the unit is approximately 250 feet downhill from the road and is defined by a small creek and the south boundary of Section 6. The closest possible spot for a landing was located 1600 feet from the plot along the road. A number of narrow corridors were established across the plot and the trees were cold decked in a continuous pile along the road.

To develop a record of stand characteristics before and after thinning, twelve 1/20th acre circular inventory points were installed. Plot centers were located systematically on a grid of 80 feet throughout the unit. Before thinning, the stocking was approximately 780 stems per acre. The average stem was 5.1 inches in diameter at breast height (d.b.h.) and the basal area per acre was 161.7 square feet. Fifty eight percent of the stand was ponderosa pine and the rest was Douglas fir. The stand composition following thinning consisted of 61 percent ponderosa pine and 39 percent Douglas fir. The average d.b.h. of the two species was 8.4 inches and the basal area was 104.6 square feet per acre. The stand table on the following page is a summary of the inventory data collected before and after thinning.

TREATMENT PLOT 2
PRE and POST - THINNING STAND TABLE
(Values are listed on a per acre basis)

DBH Class	Number Of Trees		Basal Area in Sq. Ft.		Total Stem Vol. in Cubic Feet	
	Pre	Post	Pre	Post	Pre	Post
1	60.0	0	.5	0	3.75	- 0
2	130.0	3.3	3.0	.1	28.37	.79
3	115.0	3.3	5.8	.2	71.83	2.59
4	105.0	15.0	9.5	1.5	150.40	24.76
5	83.3	20.0	11.4	2.8	201.44	50.82
6	80.0	30.0	16.0	6.0	308.41	116.25
7	51.7	28.3	14.1	7.9	290.93	164.00
8	50.0	38.3	17.2	12.9	356.11	269.17
9	23.3	21.7	10.1	9.4	217.37	205.21
10	23.3	21.7	12.6	11.7	281.91	261.81
11	10.0	8.3	6.6	5.4	150.72	123.43
12	13.3	13.3	10.4	10.4	239.07	239.07
13	13.3	10.0	12.3	9.2	278.52	214.70
14	10.0	8.3	10.7	9.0	246.92	213.42
15	5.0	5.0	6.1	6.1	140.32	146.00
16	0	0	0	0	0	0
17	1.7	1.7	2.5	2.5	58.64	61.01
18	1.7	1.7	3.1	3.1	71.83	74.74
19	5.0	3.3	9.8	6.4	223.86	145.85
TOTALS	781.7	233.3	161.7	104.6	3320.4	2317.23

The totals listed represent the average value of that perameter on a per acre basis for the entire stand. A divisor of 35.33 can be used to convert total stem volume from cubic feet to cubic meters.

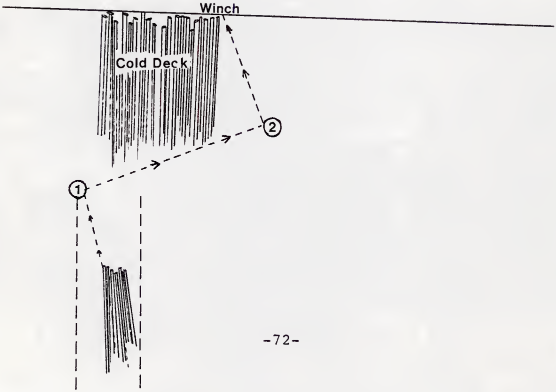
PLOT TREATMENT

The main objectives in treating this plot were to first; thin the stand to a spacing of 14x14 feet; second, demonstrate the use of the farm tractor winch to remove all thinned material suitable for hog fuel; and third, remove this material without causing extensive damage to the residual stand. As stated earlier, the nearest possible area for a processing landing was located approximately 1700 feet down the road from the plot. Therefore, we used a slightly different approach to stockpile turns than on Milestone 2. Trees were decked perpendicular to the road in a continuous pile along the top of the plot. This decking method was used for a number of reasons. First, there was the long skid distance to the landing. Second, we wanted to test the system with as few people and machines as possible -- a crew configuration most likely to be used by a small woodlot operator. This approach eliminated the grapple-equipped tractor and operator that we used to swing material away from the winch in Milestone 2. Third, because of the long skid distance, we felt that it was not feasible to swing bunches with the tractor winch while the rest of the crew waited for it to return. Also, the tractor equipped with only the winch, would be unable to heel material into a cold deck. As a result, the limited landing area would soon become plugged with piles. Fourth, because the plot was only 250 feet wide and only a portion of the standing trees would be removed, we felt that there was adequate room to cold deck material adjacent to the road.

A three-person crew did both the thinning and yarding. While thinning, the crew consisted of one sawyer and two stackers. Prior to thinning a strip, the crew would locate a corridor that provided access to decking areas along the road. Working from the bottom to the top the plot, the crew would fall and bunch stems in the traditional herringbone pattern along either side of the corridor. Leave trees were selected which would not interfere with the yarding phase of the operation. We also emphasized the importance of obtaining 235 quality leave trees per acre over the entire plot, rather than an exact spacing of 14 feet between trees. With these guidelines the crew removed 535 trees per acre and left approximately 230 trees per acre, a spacing of 13.7 x 13.7 feet. Once the corridor was thinned and piled, the same three person crew yarded bunches to the road. One person operated the winch, unhooked incoming turns and moved the tractor as needed. He used a voice-actuated, fm radio to communicate with the woods crew. The other two crew members were in the woods along the corridor. One person was responsible for selecting turns, presetting choker chains and rigging lower breakaway blocks where needed. The second person retrieved the winch line and choker chains after each turn, rigged breakaway blocks along the top of the corridor and signaled the winch operator with the radio when a turn was ready to be winched. After a turn was yarded and the winch line and chokers were hauled back down the hill, these two people would alternate jobs. This enabled the person retrieving the winch line and chokers to rest briefly before his next trip up the hill.

Turns consisting of two to three bunches were directed into the corridor with breakaway blocks and then yarded to the top of the plot. To fully utilize landing space, additional turns were yarded over the top of the previous ones and decked 2 to 3 high. As the area behind the winch became full, the tractor was moved down the road approximately one turn width, and the process was repeated. The tractor was moved while the winch line was being hauled back down the hill.

We used two techniques to deck turns at the tractor. The first was for turns which were piled directly in-line with the corridor. By placing a breakaway block 6 to 8 feet high in a tree on one side of the corridor, we were able to lift the butts of the incoming turn over the tops of the previous drag. As the block tripped, the turn would fall on top of the previously decked material. Thus, the butts of the incoming turn would not snag the tops of the previous drag and disrupt the pile. In the second technique, we used two blocks. The first was located across the corridor and downhill from the second block, which was hung eight to ten feet high in a tree alongside the landing. The tractor winch was positioned along the road adjacent to the previously yarded turns. The winch line was run from the tractor through the second block, across through the first block and down the hill to the pile. As a turn was being yarded, the first block aligned it in the corridor regardless of tractor position. Once the first block was tripped, the turn would cross the corridor avoiding the tops of the previously decked bunches. The second block then lifted the turn over the tops of the decked material in the same manner as the single block in the first technique. As this second block tripped, the turn aligned itself with the winch and the deck. The following diagram illustrates this technique:



To reach 250 feet to the bottom of the plot we increased the winch drum capacity from 220 feet to 350 feet. By replacing the standard 3/8 inch cable with 5/16 inch we were able to spool an additional 150 feet of line on the winch. The additional footage also allowed greater flexibility in corridor layout by increasing the amount of line available for lateral yarding. With a breaking strength of 9000 pounds, the 5/16 inch cable exceeded the pulling capacity of the winch mounted on a 50 hp. tractor operated at the recommended p.t.o. speed.

As previously noted, bunches were yarded to the road and cold decked until both Plots 2 and 3 were completed. At that time the material was skidded down the road to a processing landing where it was chipped into hog fuel. Midnight Harvesting of Huson, Montana, contracted the swing and processing phase. They used a John Deere model 540 glapple skidder to move the bunches an average distance of 1850 feet from the cold decks to the chipper. Despite the long skid, the skidder maintained a continuous flow of material to the chipper.

PRODUCTION RATES

Two types of hourly figures are listed. Net hours are the time in which the crew or machine was actually operating. The second, total working hours, includes both operating hours and associated time such as breakdowns and the moving of machinery. Production rates are reported in terms of stems per hour. However, it should be noted that when comparing production rates amoung treatment plots, stems per hour should be converted to cubic feet. To make this conversion a multiplier of 1.72 is used. This is the volume in cubic feet of the average size piece removed and is equivalent to a 3.9 inch d.b.h. tree, 27 feet tall. It was derived from sampling the stems in one out of every six piles constructed by the thinning crew.

Felling and Bunching:

The three person crew fell and bunched 1659 stems in 21.5 total crew working hours -- an average of 77.2 stems per hour or 25.7 stems per crew member per hour. Using a factor of 1.72, this is equivalent to 44.72 cubic feet per crew member hour.

Yarding:

During yarding, the crew winched 116 turns in 22 total crew working hours for an average of 5.3 turns per hour. Based on total net hours the crew winched 6.4 turns per hour. Each turn contained an average of 1.7 bunches with 8.2 stems per bunch, or approximately 74 stems per crew hour. This is equivalent to 127.1 cubic feet of wood per working crew hour. The table on the following page summarizes the major production data from the winching phase of the operation.

Item	Amount
Yarding Crew	3 people
Total stems Yarded	1659
Average yarding distance	150 feet
Total turns	116
Average number of stems per turn	14-15
Average number of bunches per turn	1.7
Winch operational hours	18.25 hours
Winch down time	3.75 hours
Total winching time	22.0 hours
Total crew time	66.0 hours
Tractor fuel used	8.1 gallons
Average fuel used per hour	.37 gallons

Swing and Processing:

Midnight Harvesting used two people, the J.D. 540 skidder and and a Morbark Model 12 Chiparvester in the combined swing/processing phase. They produced 65.57 tons of whole-tree chips in 10.5 total working hours. This was equivalent to 52.13 units of chips or an average of 16.82 units per acre. One unit is equivalent to 200 cubic feet of whole-tree chips or approximately 71.4 cubic feet of solid wood. The chipper knives were changed twice because of dirt that had accumulated on the trees from the long skid down the road. Each knife change took about 30 minutes and this time is included in the working hours.

During the 10.5 hour period, the 540 J.D. grapple skidder moved approximately 1650 stems an average skid distance of 1850 feet. In that time it consumed a total of 26.25 gallons of fuel or 2.5 gallons per hour. The chipper used 6 gallons of fuel per hour for an average of .87 gallons per 200 cubic foot unit.

TREATMENT PLOT 3

PLOT DESCRIPTION AND LAYOUT

Treatment Plot 3 is located just uphill from Treatment Plot 2 in stand conditions that are somewhat similar. The area is .94 acres with slopes ranging from 30 to 45 percent. The bottom of the unit extends 275 feet along the Morrison Peak Road which separates Plots 2 and 3. The top of the plot is approximately 150 horizontal feet uphill from the road. As with Plot 2, the nearest feasible landing location on the road was located 1700 feet east of the plot.

Using three 1/20th acre inventory points on a grid of 80 feet, stand characteristics before and after thinning were obtained in the same manner as on Plot 2. The pre-thinning inventory estimated a much higher number of trees per acre than on Plot 2, but the average stem was slightly smaller. Before thinning, the stand consisted of 78 percent ponderosa pine and 22 percent Douglas fir. The combined stocking of the two species was approximately 1100 trees per acre. The average tree was 4.4 inches d.b.h. and the basal area per acre was 147.9 square feet. Following thinning, the stand composition consisted of 77 percent ponderosa pine and 23 percent Douglas fir. The average d.b.h. of the two species was 6.7 inches and the basal area was 64.6 square feet per acre. The stand table on the following page is a summary of the inventory data collected before and after thinning.

PLOT TREATMENT

As with Plot 2, the objective on this unit was to thin the stand to a spacing of 14x14 feet. However, in this instance we would use the farm tractor winch to yard material downhill. To remain consistent with Plot 2 we used a three person crew and one tractor. Once again all material suitable for hog fuel was removed from the stand and cold decked for later processing. Although the trees were processed using the same technique as applied in Plot 2, we used a slightly different approach to thinning, yarding and decking on Plot 3.

Because of the narrow road and the 3 to 5 foot high cut bank, it was very difficult to deck more than one turn at the winch without moving the previous turn out of the way. Also, on many corridors, the winch line was actually at ground level as it left the winch fairlead. As a result there was not sufficient lift to deck one turn on top of the other. This lack of lift, coupled with gravity working in the direction of the piles' movement, also made it difficult to control the direction and alignment of the incoming turn.

TREATMENT PLOT 3

PRE and POST - THINNING STAND TABLE
(Values are listed on a per acre basis)

DBH Class	Number Of Trees		Basal Area in Sq. Ft.		Total Stem Vol. in Cubic Feet	
	Pre	Post	Pre	Post	Pre	Post
1	63.0	0	.5	0	3.18	0
2	183.3	0	4.5	0	35.29	0
3	183.3	13.3	9.6	.7	101.68	8.10
4	210.0	13.3	18.6	1.3	240.06	17.25
5	156.7	33.3	22.3	4.9	330.88	80.96
6	133.3	53.3	26.7	10.6	423.27	177.52
7	76.7	43.3	19.9	11.1	328.0	199.41
8	40.0	36.7	14.7	13.3	251.36	235.99
9	20.0	20.0	8.8	8.9	157.67	163.27
10	20.0	10.0	11.0	5.6	202.75	108.56
11	6.7	6.7	4.4	4.4	79.70	85.62
12	0	0	0	0	0	0
13	3.3	0	3.1	0	55.23	0
14	3.3	3.3	3.8	3.8	77.75	77.75
TOTALS	1099.6	233.2	147.9	64.6	2286.82	1153.84

The totals listed represent the average value of that parameter on a per acre basis for the entire stand. A divisor of 35.33 can be used to convert total stem volume from cubic feet to cubic meters.

To overcome these difficulties, we modified the felling crew configuration and thinning sequence. The two person crew, consisting of one sawyer and one stacker, felled the trees with the butts pointed toward the closest corridor landing. Unlike on Plot 2 where the crew thinned strips at right angles to the road, on this unit they started at the bottom of the plot and thinned a strip parallel to the road.

The width of the strip was determined by the average tree length and the amount of material being removed. Once the strip was completely thinned, the entire crew yarded the bunches to the road in the reverse order from which they were piled. This prevented any overlapping piles from being pulled apart as they were yarded. After one corridor was filled with material, usually 1 to 3 turns, the tractor moved to the next corridor and the process was repeated. We used the same yarding crew configuration as on Plot 2 to winch the piles down to the road. The first person operated the winch, unhooked incoming turns and moved the tractor along the road. The remaining two crew members were located uphill from the winch. One person was responsible for selecting turns and presetting choker chains on piles. The second person retrieved the winch line, hooked prechokered piles and signaled the winch operator with the radio. Breakaway blocks were set by both crew members as needed. Because of the physical effort required to drag the winch line and chokers back up the hill, these two crew members alternated turns in retrieving the winch line.

When all accessible corridor landings were full or the strip completed, the tractor operator replaced the winch with the grapple -- a process that averaged 15 minutes for the complete change. The change-over time, which totaled 1.5 hours for the plot, was included in the swing operation as downtime and has no effect on yarding time.

Starting with the turns winched last, piles were moved from the the corridors down the road to openings where they were heeled off the road into cold decks for later processing with the material from Plot 2. During this swing operation, the other two crew members began thinning and bunching the next strip. By the time the tractor operator finished swinging material and replacing the grapple with the winch, the thinning crew had (in most cases) completed the next strip and were ready to resume yarding. In those instances where the tractor operator finished swinging material before the stip was thinned, he would help the thinning crew complete the strip.

PRODUCTION RATES

As with Plot 2, production rates are reported either as number of stems per operational hour or working hour. To convert stems per hour to cubic feet, a multiplier of 1.42 is used. Once again this is the total stem volume of the average size piece removed and is

equivalent to a four inch d.b.h. tree, 25 feet tall. Although the average tree removed on this plot was slightly larger in diameter than it's counterpart on Plot 2, the average height of the trees was shorter, which resulted in a lower cubic foot volume per piece removed.

Felling and Bunching:

We kept separate hourly production figures for both the two and three person thinning crews. The two person crew averaged 58 trees per crew hour or approximately 29 trees per crew member hour. However, the three person crew averaged only 55 stems per hour or 19 stems per crew member hour. There are two main reasons for this difference. First, the steepness of the plot and the size of material being removed did not justify a second stacker. As a tree was cut, one stacker could directionally fall and pile the tree in sufficient time to assist the sawyer with the next tree. The stacker also used the slope of the plot adventageously to throw the butts of trees downhill into piles. Second, these figures are based on total working time which includes downtime. The downtime, which usually involved minor saw maintenance, then resulted in the unproductive time of three crew members rather than two of the smaller crew.

Both crews combined felled and bunched 925 stems in 17 total working crew hours for an average of 54.7 stems per hour.

Yarding:

During yarding operations the crew winched 62 turns in 6.5 total working hours for an average of 9.5 turns per hour. The average turn contained 1.9 bunches. With an average of 7.7 stems per bunch, approximately 142 stems were winched per crew hour. Multiplied by 1.41 cubic feet per stem, this is equivalent to 200.2 cubic feet of wood per working crew hour. Although the volume of the average stem was slightly smaller on Plot 3, production was 73 cubic feet per crew hour greater than on Plot 2. By nearly doubling the number of turns per hour, the crew also moved twice the number of stems per hour. However, the significant difference in the production rates between the two plots does not include swinging and cold decking on Plot 3. When we include the additional six hours of swinging and cold decking time plus the 1.5 hours of downtime for changing the winch to the grapple and vica-versa, the production rates in Plot 3 are slightly less than those on Plot 2. For example, on Plot 2 the crew simultaneously yarded and cold decked approximately 127 cubic feet of wood per hour. On Plot 3 the crew yarded an average of 200 cubic feet per hour. However, when swinging and cold decking is included, the crew averaged only 101 cubic feet per hour. The table on the following page summarizes the major data from the winching stage of the operation.

Item	Amount
Winching crew	3
Total stems yarded	925
Average yarding distance	100 feet
Total turns	62
Average number of stems per turn	14.9
Average number of bunches per turn	1.7
Winch operational hours (total)	6.5
Downtime (winch to grapple change over) hours seperate from winch hours	1.5
Total crew time	19.5
Tractor fuel used	2.4 gallons
Average fuel per hour	.37 gallons

As part of a formal demonstration on Treatment Plot 5, we tested the technique used on Plot 3 in an uphill yarding situation. During the short period of time that the system was tested, the crew yarded an average of 11 turns per hour over a mean yarding distance of 65 feet.

Swing:

The tractor and grapple were operated a total of 7.5 hours in the swing and decking of material. This included the 1.5 hours of downtime to change over the grapple and winch. During this time the operator moved approximately 105 stems per hour an average distance of 550 feet. The J.D. 2240 farm tractor used approximately four gallons of diesel fuel for an average of .50 gallons per hour.

Processing:

The contract processing crew produced 27.9 tons of whole-tree chips in 4 total working hours. This was equivalent to 21.48 total units of chips or an average of 22.85 units per acre. Once again, a unit is 200 cubic feet of whole-tree chips or approximately 71.4 solid cubic feet of wood. Hourly fuel consumption for both the skidder and the chipper were essentially the same as on Plot 2. The skidder operated a total of 4 hours and in that time moved approximately 925 stems an average distance of 1300 feet. The working time includes thirty minutes of downtime for changing chipper knives.

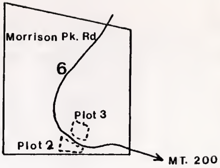
TECHNICAL TRANSFER

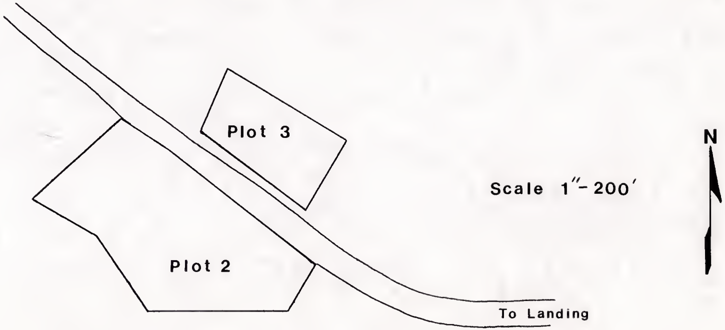
Although no formal demonstrations were conducted on either Plots 2 or 3, we did establish an area adjacent to Montana Highway 200 for demonstrating the winch system. This location is easily accessible from the Lubrecht Forestry Center and is incorporated into a formal thinning demonstration area established in 1981. The area also provides an ideal setting for demonstrating the Bitterroot Miniyarder. Using the information and techniques developed on Plots 2 and 3, we conducted two formal tours involving the winch at this location.

Group	Number of Particpants
Montana Tree Farmers Association	80
Silviculture Class	30

The winch was also demonstrated in conjunction with the Bitterroot Miniyarder on Milestone 2 and on Treatment Plots 1 and 5.

MILESTONE # 4
Treatment Plots 2 + 3
Sec. T13N. R15W





APPENDIX E

MILESTONE REPORT 5

TREATMENT PLOT 4

MILESTONE # 5 - TREATMENT PLOT 4

PLOT LOCATION

Treatment Plot 4 is located in the SE1/4 SW1/4 of Section 2, Township 13 North, Range 14 West, Montana Principal Meridian, Missoula County, Montana. The plot, situated immediately south of Little Fish Creek, is on land administered by the Division of Forestry, Montana Department of State Lands. Access to the area from Montana Highway 200 is via Missoula County Road # 62 and Champion International Corporation's Little Fish Creek Road. This location was chosen for two reasons. First, this general area has extensive stands of lodgepole pine on steep terrain and the tree sizes are ideally suited for yarding with both the Miniyarder and the larger Clearwater yarder. Second, the Department of State Lands and Champion Timberlands are cooperators in the project and both organizations wanted small treatment plots on their ownership to test the feasibility of using small machines to yard post/pole and pulpwood-sized lodgepole pine. As a second part of Milestone 5, we plan to install a plot on Champion ownership in this same vicinity.

PLOT DESCRIPTION AND LAYOUT

The three acre Little Fish Creek Lodgepole Plot consists of two subunits. The first is a 2.0 acre tract that was yarded with the Bitteroot Miniyarder and is the basis of this milestone report. The second subplot is a 1.0 acre parcel that will be yarded with the Clearwater Yarder as part of Milestone Number 7. The area treated with the Miniyarder is 210 feet wide along the Little Fish Creek Road and extends 430 feet downhill on at average slope of 27 percent. The bottom of the unit is approximately 100 feet from the creek. We located the Miniyarder on the road and used three corridors to yard the unit in two settings. The eastern portion of the unit was yarded from the first setting using one corridor and the western portion was yarded from two corridors that originated from the second setting. We used a farm tractor with grapples to skid the material from the yarder to a decking area which was located along the road 700 feet northeast of the unit.

The entire three acre plot is located in a mixed stand of western larch and lodgepole pine. In their silvicultural prescription for the area, the Division of Forestry asked us to remove all the lodgepole pine and leave the western larch as a seed source for the succeeding crop of trees. For inventory purposes we established 10, 1/20th acre circular plots on the three acres in a systematic pattern. Information from these plots was processed in a computer program to generate the tree and stand data cited in this report. The table on the following page lists stand data on a per acre basis by species prior to treatment.

PRE-TREATMENT STAND TABLE

(Values are listed on a per acre basis)

DBH Class	Number of Trees			Basal Area in Square Feet			Total Stem Volume in Cubic Feet		
	WL	LPP	Total	WL	LPP	Total	WL	LPP	Total
2	0	4	4	0	1	1	0	2	2
3	0	30	30	0	2	2	0	38	38
4	4	50	54	1	4	5	6	125	131
5	10	70	80	1	10	11	34	285	319
6	12	122	134	2	25	27	71	760	831
7	2	132	134	1	35	36	17	1,161	1,178
8	10	86	96	4	30	34	103	1,026	1,129
9	12	50	62	5	22	27	156	752	908
10	10	18	28	6	9	15	182	335	517
11	8	2	10	5	1	6	169	45	214
12	6	0	6	5	0	5	152	0	152
13	2	0	2	2	0	2	59	0	59
14	0	0	0	0	0	0	0	0	0
15	4	0	4	5	0	5	169	0	169
TOTALS	80	564	644	37	139	176	1,118	4,529	5.647

The totals listed in the above table represent the average value of that parameter on a per acre basis for the entire stand. A divisor of 35.33 can be used to convert total stem volume from cubic feet to cubic meters. For example, the stand contained an average of 31.64 cubic meters of western larch and 128.19 cubic meters of lodgepole pine for a total of 159.83 cubic meters of total stem volume per acre. The lodgepole pine figures are the most significant because we removed all the lodgepole from the stand. The average piece size is obtained by dividing the total stem volume in cubic feet by the total number of stems per acre. The average lodgepole pine was 6.8 inches in diameter, 56 feet tall and contained 8.03 cubic feet or .227 cubic meters.

PLOT TREATMENT

The primary object of the treatment was to remove all the standing lodgepole pine (both live and dead) and leave the western larch as seed trees for the succeeding crop. We removed approximately 565 trees per acre and left 80 trees standing per acre. Although this treament was not a clearcut, it did allow us more room for yarding than was available in Milestone # 3. The 80 stems per acre of western larch is equivalent to a 23 foot spacing. The Division of Forestry did not want to burn slash on the plot, so we yarded full trees to the road. In the process of skidding the turns away from the yarder, the tops were cut off at an approximate top diameter of four inches. The tops were shingle stacked on the uphill side of the road for future chipping and the bucked stems were skidded down the road to a landing where they were decked for later removal. Because we wanted to treat the plot in a one week time period, we used a large crew to do the work. We had two people felling and bunching, three people on the yarding crew and two people on the swing/processing crew.

In Milestone # 3, felling and bunching concurrently with the yarding appeared to be more efficient than separating the functions. Although combined felling/yarding requires close coordination between the two crews, we decided to use this method on this treatment block. Because the trees were too large to bunch, we used a two person felling crew consisting of a feller and a pusher. They fell the trees either downhill or in a herringbone pattern with the tree butts facing the skyline corridor. First they felled the skyline corridor. While these trees were being yarded, the crew started at the bottom of the corridor and fell a swath 50 feet wide up one side of the line for 60 to 80 feet. Then as the yarding crew worked on that parcel, the felling crew moved across the line and cut a similar-sized swath. After the bottom part of the corridor was yarded, the felling crew used a technique whereby they dropped one tree at right angles to the corridor and then a row of trees downhill on top of the cross tree. This method allowed the yarding crew to pull the trees across the hill on the slide log, which reduced the potential of hangups. To increase yarding efficiency, the crew bucked trees in the 10 to 12 inch butt diameter range which were 80 plus feet tall. After felling was complete on one corridor, the crew moved to the next one and cleared a strip for the skyline.

The yarder crew consisted of three people, one at the landing and two in the woods. The person at the landing operated the yarder and unhooked the incoming turns. He also used a small, voice actuated, fm radio to communicate with the two people in the woods. We used four chokers in this operation. One of woods crew usually preset chokers while the preceeding drag was being yarded. In this size timber, a normal turn consisted of approximately two trees. The person presetting chokers was also responsible for selecting turns and setting breakway blocks as needed to avoid damage to the

residual larch. The duties of the second crew member in the woods included operating the fm radio, moving the skyline stop, and hooking the mainline to the preset chokers.

Two primary products were recovered from the yarded material - poles in either 20 or 40 feet lengths and hogfuel. The swing and processing phase was performed by a two member crew. One person operated the grapple-equipped John Deere model 2940 four wheel drive farm tractor. After two to three turns would accumulate under the yarder, he would grapple the trees and pull them up on the road. When the drag was parallel with the road, he stopped at a designated point and the second person would limb the trees and cut the stems off at either a 20 or 40 foot length. After the tops were removed, the tractor operator skidded the poles 700 feet down the road to the landing where he decked the short poles in one pile and the longer ones in a second pile. Meanwhile, the bucker would bunch the tops and, if time permitted, assist the yarder operator in unhooking the turns. Prior to moving the next bunches from the yarder, the tractor operator stacked the tops from the previous turn in a shingle stack along the uphill side of the road. When the yarding on the second subunit is completed with the Clearwater Yarder, the tops from both subunits will be chipped.

The table which follows is a summary of the roundwood material removed from the 2.0 acre subunit # 1. The amount of hogfuel recovered from this unit will be listed in the Milestone # 9 report.

Item	Total Amount.	Amount per Acre
Number of Stems	1,330	665
Number of 40 Foot Poles	689	345
Number of 20 Foot Poles	310	155
Volume of Poles in Cubic Feet	7,031	3,516
Volume of Poles in Cubic Meters	199	99

PRODUCTION RATES

The tables in this section list production rates in terms of stems per hour for various phases of the operation. Two primary types of hour figures are used. The first is that time in which the crew or machine was actually operating and the second encompasses both operational time plus associated working time including breakdown and changing skyline corridors. These figures do not reflect nonproductive time such as lunch breaks or record keeping. Although production rates are based on stems per hour, they can be converted to cubic feet by using a multiplier of 8.03.

Felling and Bunching:

The two person felling crew worked a total of 79 hours and cut a total of 969 standing trees for an average of 25 stems per crew hour or 12.3 stems per crew member hour. With the addition of 6.1 man hours added for locating and changing skyline corridors, the production per crew member hour decreased to 11.4 stems. By contrast, the production rate of the five person felling and bunching crew on Treatment Plot # 1 in Milestone # 3 was 16 stems per crew member hour. The lower production rates can be attributed to two major factors. First, the average tree on this treatment plot was more than twice as large as the average tree on Treatment Plot # 1. Second, the presence of both the yarding crew and skyline adjacent to the felling operation also lowered production rates. However, it is interesting to note that when production is calculated in cubic feet per crew member hour, rates for the two treatment areas reverse. Working hour production for this unit is 91.5 cubic feet per crew member hour versus 44.8 cubic feet per crew member hour on Treatment Plot # 1.

Yarding:

The following table lists in summary form the major data from the yarding phase of the operation:

Item	Amount	
Yarder Crew	3	people
Total stems yarded	1330	
Average yarding distance	273	feet
Total turns	770	
Average number of stems per turn	1.7	stems
Skyline corridor settings	3	
Yarder operational hours	47.0	hours
Yarder downtime (cable repair & replacement)	3.25	hours
Yarder movetime	2.5	hours
Total yarder time	52.75	hours
Total crew time	137.75	hours
Yarder fuel used	44.6	gallons
Average fuel use per hour	.95	gallons

The yarder crew moved an average of 28 stems per operational hour or 25 stems per working hour on this treatment unit. The total crew hours are not the same as three times the yarder hours because, at times, the crew consisted of only two people. The crew yarded an average of 10.7 stems per operational crew member hour. The highest production occurred over one five hour time period with a two person crew and a yarding distance of 225 feet. The crew yarded 158 trees in 106 turns for an average of 16 stems per operational crew member hour. The production in terms of stems per crew member hour were nearly identical to that experienced on Treatment Plot #1. The denser residual spacing on Plot #1 offset the larger stem size on Plot #4. As was the case in the felling production, cubic feet per crew member hour was significantly higher in this unit - a function of tree size and silvicultural prescription.

Swing and Processing Phase:

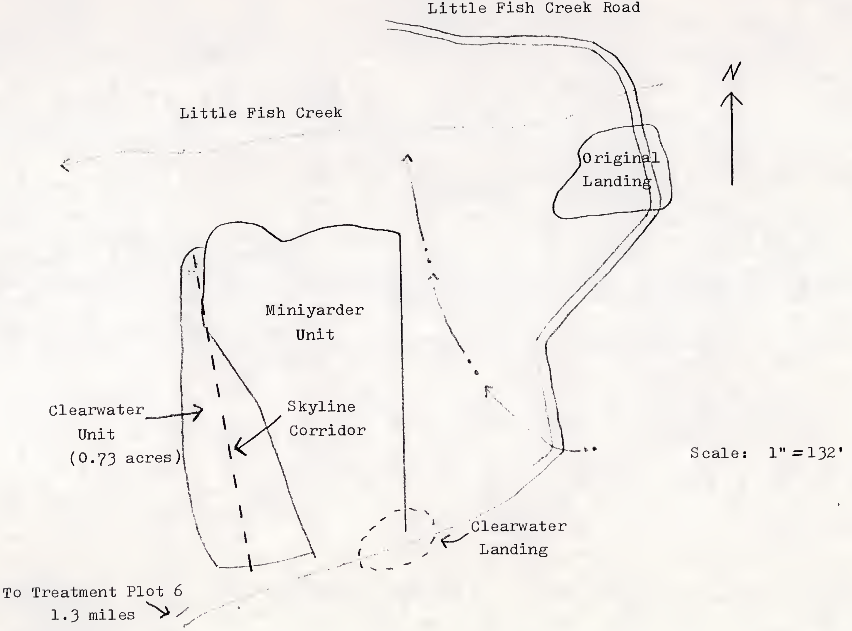
The tractor operator worked a total of 46 hours in the swing phase of the operation. In this time he removed 770 turns and 1330 trees from the yarder for an average of 17 turns and 29 stems per hour. From these trees the last crew member manufactured a total of 999 poles. She cut 689 40 foot poles and 310 20 foot poles for an average of 22 poles per hour. The tractor operator also moved the poles 700 feet down the road to the landing and shingle stacked the tops along the uphill side of the road. The 46 hour total time also includes these operations. The John Deere Model 2940 tractor used an average of .98 gallons of fuel per hour.

TECHNICAL TRANSFER

Although we did not conduct a formal demonstration on this unit of Milestone # 5, field personnel from both the Division of Forestry and Champion Timberlands viewed the operation. However, we have used information gathered from this treatment unit in group presentations and individual discussions with interested parties. Two contract loggers were particularly interested in the results as both are considering the use of small yarders in their operations.

TREATMENT PLOT #4

MILESTONE #5 & #9



APPENDIX F

MILESTONE REPORT 8

TREATMENT PLOT 5

MILESTONE # 8 - TREATMENT PLOT 5

INTRODUCTION

Milestone 8 tests and demonstrates the use of the Bitterroot Miniyarder in the removel of precommercial-sized thinning residues from a stand of second growth western larch. Material was yarded uphill on slopes in excess of 20% and then processed into industrial fuel wood (hog fuel).

PLOT LOCATION

Treatment Plot 5 is located on the Lubrecht Experimental Forest in the SE 1/4 of the NW 1/4 of Section 19 T.13 N., R.14 W., Principal Meridian Montana. The area is situated just off the Garnet Range road approximately three miles southeast of Montana Highway 200. This location was selected for a number of reasons. First, the area adjacent to Plot 5 was thinned as part of the Full-Tree Thinning Demonstration program conducted in 1982, DNRC contract number WD-LEF-012. The proximity of the two plots, in conjunction with the numerous studies that were established on the original tracts to measure stand response to thinning, would enhance the value of the entire area for tours and demonstrations. This area is also easily accessible from the Lubrecht Forestry Center. Second, this area had steep and broken terrain which provided both an ideal test, as well as an operational application, of the Bitterroot Miniyarder. Third, the stand needed precommercial thinning, and the size of material to be removed was well matched to the capabilities of the Miniyarder.

PLOT DESCRIPTION AND LAYOUT

The unit was established in a 50 year old stand of predominately western larch located on a north facing aspect that ranged from 20 to 60 percent slope. The area totals 3.9 acres and is somewhat pie-shaped (see attached map). The longest side extends 500 feet down a draw which marks the northeast edge of the plot. The top of the plot extends 625 feet along the Coyote Park Spur Road which separates Treatment Plot 5 from the Coyote Park Thinning Unit. The west side of the plot is defined by a change in timber type from second growth larch to Douglas fir.

To obtain a complete record of the stand characteristics before and after thinning, sixteen 1/20th acre circular inventory points were established. To uniformly sample the entire unit, plot centers were located systematiclly on a grid of 80 feet and permanent plot centers were marked with steel pipe. Before thinning, the stand consisted of 81% western larch, 18% Douglas fir and 1% lodgepole pine. The stocking prior to thinning averaged 1400 stems per acre. The basal area per acre was 136.5 square feet with an average diameter at breast height of five inches. The stand table on the following page is a summary of the stand inventory data taken before and after thinning.

PRE and POST - THINNING STAND TABLE
(Values are listed on a per acre basis)

DBH Class	Number Of Trees		Basal Area in Sq. Ft.		Total Stems Vol. in Cubic Feet	
	Pre	Post	Pre	Post	Pre	Post
1	320	0	2.6	0	19.1	0
2	381	0	8.7	0	86.1	0
3	238	13	11.83	.7	155.8	8.8
4	162	21	14.77	2.0	244.3	32.2
5	145	43	20.01	5.9	373.9	109.6
6	72	38	14.15	7.5	286.5	148.7
7	52	46	14.26	12.5	306.0	266.0
8	26	21	9.25	7.5	204.3	164.9
9	11	8	5.1	3.5	115.4	81.1
10	10	10	5.5	5.1	119.3	115.7
11	5	5	3.3	3.1	71.8	67.9
12	3	1	2.1	.9	50.5	21.4
13	1	0	1.1	0	26.0	0
14	1	0	1.3	0	31.0	0
15	4	1	4.8	1.7	111.3	40.5
16	0	0	0	0	0	0
17	2	2	3.9	3.7	134.0	125.2
18>	5	4	13.8	10.2	462.2	302.2
TOTALS	1434	213	136.5	64.3	2797.5	1484.5

The totals listed represent the average value of that parameter on a per acre basis for the entire stand. A divisor of 35.33 can be used to convert total stem volume from cubic feet to cubic meters. The stand composition following thinning was 94% western larch, 4% Douglas fir, and 1% lodgepole pine.

Four yarder landings were located approximately 100 feet apart along the road at the upper edge of the plot. Three of the corridors were yarded during December and the remaining one was completed the following spring. We divided this treatment period for two reasons. First, because the area is accessible from the Lubrecht Forestry Center, we wanted to use the plot for tours and workshops scheduled in the spring. Second, we wanted to compare results of thinning and yarding western larch in the dormant versus the active stage of the trees. Although production rates were similar for the two time periods, the residual stand did accrue a significant amount of bark damage during spring yarding.

PLOT TREATMENT

The primary treatment objectives on this precommercial stand were first, to thin to a spacing of 14x14 foot and second, to remove all thinned material suitable for hog fuel without causing extensive damage to the residual stand. The thinning crew selected leave trees during thinning operations; however, we emphasized the importance of obtaining 235 quality leave trees per acre over the entire plot. Using these guidelines the crews removed 1200 stems per acre and left approximatly 213 stems per acre, a spacing of 14.3 x 14.3 feet.

The system we used to treat the area can be broken down into four stages. The first consisted of falling and bunching the stems into piles for yarding. This was done in much the same manner as on the other treatment plots. However, because of the nature of the stand and the steep terrain, we found that the two person crew not only worked more safely, but also was slightly more productive than the traditional three person crew which we used on flatter ground. The two person crews also provided an even division of the four person crew used in the yarding and swing stages of the operation.

The second stage consisted of yarding bunches to the landing. Once the corridor was completely thinned and piled, bunches were yarded using three of the four crew members who where responsible for thinning. We used the same crew configuration as described for Treatment Plot 4. The first person operated the yarder and unhooked the incoming turns. He also used a voice actuated, fm radio to communicate with the woods crew. The other two crew members were located down the corridor. One person was responsible for selecting turns and presetting chokers on piles. The other crew member would retrieve the main line from the skyline carriage, hook prechokered piles and signal the yarder operator with the radio. This person was also responsible for moving the skyline stop and assisting in setting breakaway blocks which were used to prevent hang-ups.

In the third stage, the fourth crew member moved material from the yarder to the processing area, which was located at the southwest corner of the plot. To swing material from the yarder to this processing landing, we used a 2240 J.D. farm tractor equipped with grapples. At the landing, bunches were heeled into a shingle

stack-type cold deck for later chipping into hog fuel. It was 600 feet from the farthest corridor to the cold deck. The few large merchantable trees that were yarded were skidded to the landing, bucked to specified lengths and decked into a seperate pile. The tops from these trees were also heeled into the shingle stack.

The last stage involved the processing of stems into hog fuel, which was the primary product recovered from this plot. We used a Morbark Model 12 portable chipper in conjunction with the farm tractor which was used to skid material from the shingle stack to the chipper. Chipping was done simultaneously with the yarding of the last corridor which was located closest to the landing. This enabled us to keep the tractor busy because the operator could supply the chipper with material from the shingle stack between trips to the yarded. Without this additional function of supplying the chipper, the tractor would have been idle much of the time because of the shorter distance from the corridor to the landing.

PRODUCTION RATES

As with the other treatment plots, two types of hour figures are listed. The first, net hours, is that time in which the crew or machine was actually operating. The second, total hours, includes both operational time and associated working time, including breakdowns and relocation of the skyline. Production rates are reported as stems per hour. However, it should be noted that when comparing these production rates with those from other treatment plots, the stems removed from this plot were smaller in diameter and therefore more could be handled at one time. To convert stem production rates to cubic foot volumes a multiplier of .93 is used. This is the total stem volume in cubic feet of the average size piece removed.

Felling and Bunching:

On the first corridor the three person crew felled and bunched 1344 stems in 30.0 total working hours, an average of 44.8 stems per crew member per hour. Two person crews thinned the remaining corridors, and they cut and bunched 2864 stems in 62.0 total working hours, an average of 46.2 stems per crew member per hour. These stem counts vary slightly from the inventory data because the thinning crews did not tally small stems that may have been recorded on the inventory. Although there was only a difference of 1.4 stems per crew member hour between the different-sized crews, we felt that it was more effective to divide in half the four person crew needed for the yarding and swing stages rather than use only a part of the crew for thinning. The sawyers also found it much safer and easier to work without the foot traffic of the third person. Depending upon length and steepness, it took between six to eight hours to thin a 50 to 60 foot wide strip the length of one side of the skyline corridor. With two, two-person crews, a corridor could be thinned one day and yarded the next. We chose the 100 foot corridor widths, 50 feet on either side of the skyline, to minimize the

the number of breakaway block sets required to yard bunches around residual trees. However, we did use the blocks on a number of occasions to prevent hang-ups on large partially decomposed stumps and debris left from previous logging.

Yarding Stage:

Once a corridor was thinned, the four crew members rigged the yarder at the predetermined landing location. On the four corridors, set-up times ranged from 1/2 - 1 1/2 hours with an average of 75 minutes. An additional 20-30 minutes was spent taking down the yarder once the corridor was completed. During yarder operations the three person crew moved 409 turns in 32.5 total working hours. At an average of 10 stems per turn, approximately 165 stems were yarded per net crew hour. Once again, the significant difference in the number of stems yarded per crew hour on this plot compared with the other Miniyarder plots, was the result of the small stem size. In contrast, the production in cubic foot volumes removed per crew hour was significantly lower than on the other treatment plots. For example, on Plot 4 the crew yarded an average of 28 stems per hour which was equivalent to 225 cu. ft. per hour. The crew on Plot 6 yarded 165 stems per net crew hour, an equivalent of only 153 cubic feet per hour.

The following table summarizes the major data from the yarding stage of the operation.

Item	Amount
Yarding Crew	3 people
Total stems yarded	4050 stems
Average yarding distance	275 feet
Total turns	409
Average number of stems per turn	8-10 stems
Skyline corridor settings	4
Yarder operational hours	24.5 hours
Yarder downtime	.5 hours
Yarder movetime	7.5 hours
Total yarder time	32.5 hours
Total crew time	82.5 hours
yarder fuel used	20.8 gallons
Average fuel used per hour	.85 gallons

Swing Stage:

The grapple-equipped tractor was operated a total of 25 hours. In that time the operator moved 162 stems per hour an average skid distance of 325 feet. As the yarder landings got closer to the processing area, less tractor time was spent travelling to and from the landing. As a result, the tractor operator waited longer for a grapple load to accumulate at the yarder. To better utilize the idle time on the last corridor, which was located only 180 feet from the landing, the tractor also skidded material from the cold deck to the chipper. This constituted about half of the total operating time of the tractor on this corridor. However, the added stage did not interfere with yarding operations and the number of stems per hour moved to the processing area from the yarder remained essentially the same. The 50 h.p. Model 2240 J.D. tractor used an average of 4 gallons of diesel fuel per day, an average of .50 gallons per hour.

Processing Stage:

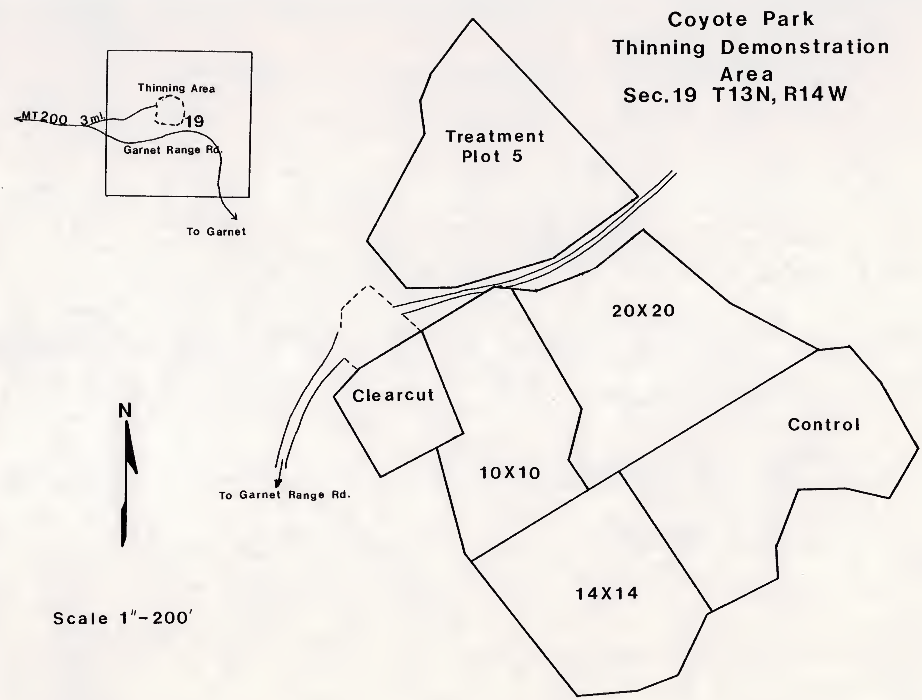
We recovered a total of 75.69 green tons of full-tree chips from this 3.9 acre plot. This was equivalent to a total of 38.99 bone dry units of chips or an average of 10 units per acre. One unit is equivalent to 2400 bone dry pounds of wood. The chipper operated 7.2 net hours and produced 5.4 units of chips per hour. The chipper used 6 gallons of fuel per hour or an average of .9 gallons per unit of chips. In addition to the net operating time, approximately 2 hours where spent unclogging the chipper. This time was not included in production rates because the frequent plugging was caused by a faulty chipper spout which we felt should have been repaired by the chipper contractor.

TECHNICAL TRANSFER

During the course of the Spring operation we conducted three formal demonstrations.

Group	Number of Participants
Salish Kootenai Community College	12
Resource Evaluation Program Forestry Students	21
Rancher, Landowner Workshop	27

To further enhance this area as a permanent demonstration area we plan to install informational signs to help identify treatments on both Plot 5 and the preceding full-tree thinning demonstration plots.


Coyote Park
Thinning Demonstration
Area
Sec. 19 T13N, R14W
Thinning Area
MT200 3 mi.
19
Garnet Range Rd.
To Garnet
Treatment
Plot 5
20X20
Clearcut
Control
10X10
14X14
To Garnet Range Rd.
N
Scale 1″–200′

APPENDIX G

MILESTONE REPORT 9

TREATMENT PLOT 6

MILESTONE # 9 - TREATMENT PLOT 6

INTRODUCTION

Milestone # 9 is made up of three parts. The first subunit consisted of a single setting for the Clearwater Yarder on Treatment Plot 4. The purpose of this test was to compare production rates of the Clearwater and Miniyarder in a thinning situation. In the second and major subunit, we used the Clearwater in a lodgepole pine clearcut on Treatment Plot 6. Finally we yarded one corridor on Treatment Plot 6 with the Bitterroot Miniyarder to compare production results with the Clearwater. In this report the subunits will be discussed separately with some general comparisons between the two yarders. A more detailed comparison of the machines will be presented in the final report.

CLEARWATER YARDER ON TREATMENT PLOT 4

PLOT DESCRIPTION AND LAYOUT

The location of the first subunit is on the west edge of Treatment Plot 4, which was described in Milestone Report # 5. The plot contains 0.73 acres and extends downhill from the road approximately 430 feet. The unit varied in width from 145 feet at the top to 30 feet at the bottom. It took three people 1.5 hours to set the Clearwater Yarder on an existing road turnout at the top of the area. We used a rubber-tired grapple skidder and a grapple equipped farm tractor to move the trees from the yarder to the decking area. The prescription on this plot was to remove all the lodgepole pine from a mixed stand of pine and western larch. The average lodgepole pine contained 8.03 cuvic feet or 0.227 cubic meters. The stand table for this area was included in the Milestone # 5 report.

PLOT TREATMENT

The treatment on this plot was similar to that described in Milestone Report # 5. The initial corridor and the bottom third of the unit was felled by a three person crew. Then as this area was being yarded, a two person crew started at the top of the setting and fell an area on one side of the skyline. When the yarding crew moved to the newly felled area, the falling crew moved to the other side of the skyline and prepared a second area. The two crews worked simultaneously, alternating sides and working their way down the corridor. The only difference between the felling procedure on this plot and the rest of the treatment area was that the crew did not have to buck the larger trees. The Clearwater had more than sufficient power to yard any of the lodgepole on the plot.

The Clearwater yarder crew consisted of three people, two in the woods and the operator. The crew functions were once again the same as with the Miniyarder as described in Milestone Report # 5 and the breakaway blocks were also used to minimize damage to the residual stand. Unlike the 1/4 inch mainline on the Miniyarder, the 3/8 inch mainline on the Clearwater made long lateral yarding more difficult. However the increased effort was offset by the increased number of stems per turn, so the crew had to make fewer trips to the edges of the corridor.

The swing and processing phase of the operation differed somewhat from the Miniyarder portion of the treatment area. The two person crew used a John Deere Model 440 grapple skidder to move the trees away from the yarder. The increased number of stems per turn resulted in larger bunches accumulating under the yarder. As a result, the skidder was more efficient than the farm tractor for both skidding the bunches to the processing area and for heeling the processed logs into decks alongside the road. The trees from this subunit were processed into pulp logs which were from 26 to 40 feet long with a top diameter on the small end of three inches. The small tops were shingle stacked for future chipping into energy wood. 406 trees were removed from the 0.73 acres for a total of 3,248 cubic feet or 92 cubic meters.

PRODUCTION RATES

Felling and Bunching:

The falling crew worked a total of 22.66 hours and cut a total of 415 standing trees for an average of 18.3 stems (146 cubic feet) per crew member hour. By contrast, the crew averaged only 12.3 stems per crew member hour on the Miniyarder portion of the treatment area. The increased production is actually a result of two factors. First the crew did not have to buck the larger logs prior to yarding with the Clearwater. Second, the decision to prefall an area at the bottom of the corridor as a starting point for the yarding crew minimized interference among the crews as they worked their way down the corridor as described previously.

Yarding:

The table on the following page lists in summary form the major data from the yarding phase of the operation. Operational time includes only that time when the machine was acutually yarding logs.

Yarding Production Summary

Item	Amount
Yarder Crew (excluding swing & processing)	3
Total stems yarded	406
Average yarding distance in feet	230
Total turns	119
Average number of stems per turn	3.4
Yarder operational hours	8.83
Yarder downtime	0
Yarder set-up time in hours	1.5
Total yarder time in hours	10.33
Total crew time	30.99

The yarder crew moved an average of 46 stems per operational hour or 39 stems per working hour when yarder set-up time is included. The crew yarded an average of 13.1 stems or 105 cubic feet per working crew hour. By contrast, the same crew averaged 28 stems per operational hour with the Miniyarder. The production rates with the Clearwater varied from 36 to 58 stems per operational hour. The higher rates were near the top of the strip and again at the bottom where there were very few western larch leave trees. The production rates were lowest in the middle one third of the strip where there were more leave trees and longer lateral yarding distances.

CLEARWATER YARDER ON TREATMENT PLOT 6

PLOT LOCATION

Treatment Plot 6 is located in the NE1/4 NE1/4 of Section 11, Township 13 North, Range 14 West, Montana Principle Meridian, Missoula County, Montana. The plot, located on land owned by Champion International Corporation, is on Champion's Little Fish Creek Road, 1.3 miles from Treatment Plot 4. It is also 400 vertical feet higher than Treatment Plot 4. As stated in the Milestone 5 Report, this area was chosen for two reasons. First, this drainage contains extensive stands of lodgepole pine on steep terrain and the tree sizes are ideally suited for yarding with both the Miniyarder and Clearwater Yarder. Second, Champion has been a

long time cooperator in our full tree harvesting and utilization studies and they wanted a plot on their land to test the feasibility of using small yarders to log pulpwood-sized lodgepole pine.

PLOT DESCRIPTION AND LAYOUT

The 3.92 acre Champion Lodgepole Plot consists of two subplots. The first is a 3.3 acre tract that was yarded with the Clearwater Yarder and the second is a 0.62 acre strip that was yarded with the Bitterroot Miniyarder. The yarding done on the 3.3 acre parcel is the subject of this portion of the report. The area treated with the Clearwater is 330 feet wide along the Little Fish Creek Road and extends downhill a distance of 525 feet. The top half of the unit has an average slope of 32 percent and the bottom half is steeper at 45 percent. We located the Clearwater on the road and used three settings to yard the unit. The first corridor extended only to the break in the slope and the remaining two went to the bottom of the plot. We used a John Deere Model 440 grapple skidder to move the material from the yarder to two separate decking areas located along the road. The decking area used for the first two corridors was located 230 feet from the western edge of the unit boundary. The logs from the third setting were decked both at the original landing and also along the road in the western portion of the plot.

Treatment Plot 6 is located in a stand of predominately lodgepole pine. However, as indicated in the Pre-treatment Stand Table, the plot also contains minor amounts of Douglas fir, western larch and subalpine fir. In their silvicultural prescription, the Champion foresters asked us to clearcut the plot. Although we had planned for a thinning operation in our original proposal for Milestone # 9, we agreed to the clearcut for two primary reasons. First, clearcutting is the normal practice in lodgepole and second, the expected higher production rates in a clearcut would yield good baseline data upon which to compare yarding production in thinning operations. Although the treatment was a clearcut, we did leave approximately 10 large western larch and Douglas fir in the upper half of the unit.

For inventory purposes we established 10 fixed circular plots (1/20th acre in size) in a systematic pattern over the entire 3.92 acres. Information from these plots was processed in a computer program to generate the tree and stand data cited in this and the following portion of the report. The table on the following page lists stand data for trees in the 5 inch DBH class and larger on a per acre basis by species prior to treatment. Although we sampled trees from the 2 inch DBH class and larger, only trees 5 inches DBH and larger were yarded from the stand. A divisor of 35.33 can be used to convert total stem volume from cubic feet to cubic meters. For example, the stand contained an average of 5,572 cubic feet or 157.7 cubic meters of total stem volume per acre.

PRE-TREATMENT STAND TABLE

(Values are listed on a per acre basis)

DBH Class	Number of Trees					Total Stem Volume in Cubic Feet				
	DF	WL	AF	LPP	Total	DF	WL	AF	LPP	Total
5	4	2	Ø	245	251	12	7	Ø	1,166	1,185
6	Ø	6	Ø	188	194	Ø	31	Ø	1,337	1,368
7	Ø	4	Ø	144	118	Ø	27	Ø	1,166	1,193
8	6	1Ø	Ø	46	62	44	97	Ø	631	772
9	2	6	Ø	12	2Ø	25	69	Ø	2Ø7	3Ø1
1Ø	6	Ø	2	2	1Ø	84	Ø	32	43	159
11	Ø	2	Ø	Ø	2	Ø	34	Ø	Ø	34
12	2	Ø	Ø	Ø	2	37	Ø	Ø	Ø	37
13	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
14	2	4	Ø	Ø	6	63	136	Ø	Ø	199
15	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
16	Ø	1	Ø	Ø	1	Ø	47	Ø	Ø	47
17	Ø	2	Ø	Ø	2	Ø	217	Ø	Ø	217
18	Ø	Ø	1	Ø	1	Ø	Ø	65	Ø	65
TOT.	22	37	3	6Ø7	669	265	665	97	4,55Ø	5,577

In addition to the totals listed above, there were 345 trees per acre (equaling 9Ø1 cubic feet) in the 2 to 4 inch DBH range. Most of these trees were lodgepole pine in the 4 inch DBH class and over 55% of the trees were dead. The average tree removed from the stand was 6.3 inches in diameter, 62 feet tall and contained a total stem volume of 8.3 cubic feet or Ø.235 cubic meters. The average piece size was obtained by dividing the total stem volume in cubic feet by the total number of stems per acre.

PLOT TREATMENT

As stated previously, because lodgepole pine was the predominate species (over 90 percent), the Champion foresters prescribed a clearcut followed by a broadcast burn for the plot. Their goal was to naturally regenerate the area with lodgepole pine. However we did leave a few large western larch and Douglas fir scattered throughout the top half of the unit to serve as a potential seed source for these species. Champion asked us also to treat the stand as a pulpwood logging demonstration. As such, we were to remove all trees that would make at least a 26 foot log to a 3 - 4 inch top diameter. All other material was left on the site as fuel for the broadcast burn. The lodgepole pine had very small crowns and although we yarded full trees to the road, most of the limbs were broken off in the yarding process. As a result, very little slash accumulated on the landing.

Unlike the procedure on Treatment Plot 4, we fell the trees on this unit prior to yarding for two reasons. First, based on our experience on Treatment Plot 4, we knew that the Clearwater Yarder would have sufficient power to yard the full trees even though the tops would be inter-twined. Second, because the Clearwater had more power and faster line speeds, we felt that falling each corridor prior to yarding would not only be safer, but more efficient. On most of the unit we used two person crews consisting of a faller and a pusher. We also worked two to three crews side by side on the corridor. Typically we would start at the bottom of the strip and work uphill with each crew responsible for its proportionate 1/3 to 1/2 of the corridor. This technique was very efficient because the pushers from one crew could help the adjacent crew to ensure that big trees or those with an uphill lean would all fall downhill. Also in the event of saw breakdown, the pusher could help the adjacent crew until the saw was repaired. The saw crews also identified and left standing those trees that would be needed for rigging the intermediate support jack. We sawed and yarded one corridor prior to beginning work on the succeeding strip.

The basic yarding crew consisted of three people, two in the woods and the operator at the landing. The person at the landing operated the yarder and unhooked the incoming turns. He also used a small, voice actuated, fm radio to communicate with the woods crew. The woods crew used four to five chokers in this operation and preset chokers whenever possible. On a typical turn one crew member would retrieve the mainline and, after giving the chokers to the other person, would pull line and hook the next turn. This crew member also had a radio and would signal the yarder operator to haul in the turn. The second person was repsonsible for setting chokers and selecting the trees for each turn. For approximately one quarter of the yarder operational time, we used three people in the woods. The third person helped pull line and chokers for the longer lateral distances. Although hooking time decreased somewhat with the third person, this system was not cost effective.

We made three settings with the Clearwater on this Treatment Area. The first corridor was only 235 feet long with the tailhold at the break in the slope. Although we had planned to use the intermediate support jack on this corridor to reach the very bottom of the unit, the Missoula Equipment Development Center had to modify the jack for the 5/8 inch skyline of the Clearwater. As a result, we used this first strip to test our techniques and become more familiar with the machine. On the final two corridors we used the intermediate support jack and accompaning carriage with the Clearwater. We had some problems rigging the intermediate support because of inexperience and lack of large trees in the desired locations. However after some trial and error, we were able to hang the rigging in the smaller trees by guying and supporting them with other small trees. To rig the intermediate support we chose two trees that were about 15 to 2Ø feet apart at the break of the slope and in line with the yarder and tailhold. We hung a sheave in each tree, approximately 3Ø feet from the ground. A 5Ø foot length of 3/8 inch cable was tied off with a choker and cable tightener to a stump located on the side and downhill of one support tree. The other end of the cable was fitted with a safety hook, put through the sheave and attached to one of the looped ends of a four foot piece of cable. The intermediate support jack has a sheave that mounted on this short length of cable. A similar attachment was used on the other support tree. When the support tree was less than 12 inches diameter breast high we also ran a guy wire from a point on the tree near the sheave block to a nearby stump. Once properly rigged, the intermediate support jack and carriage worked very well and this system maintained the necessary yarding deflection over the terrain break.

The swing and processing phase of the operation was performed by primarily a three person crew. Although we had used only two people with the Miniyarder, the increased yarding capacity of the Clearwater required three people to skid and process the trees in a smooth and efficient manner. When we were yarding from the bottom of each corridor (approximately one quarter of the time), a two person crew was able to keep up with the yarding phase of the operation. One crew member used the John Deere Model 44Ø grapple skidder to move the trees from the yarder to the bucking area. Here the operator heeled the trees off the ground and the other crew members bucked them off at an average top diameter of three inches. On the first corridor, the third person used the model 294Ø grapple equipped farm tractor to skid the logs down the road an average of 265 feet to the decking area. The great majority of the trees were processed into pulp logs with the occasional larger stems cut into sawlog lengths. The 44Ø operator pushed the limbs and tops into a burn pile located on the downhill side of the processing area.

A summary of the roundwood material removed from this portion of the Treatment Area is listed in the table on the following page.

ROUNDWOOD MATERIAL REMOVED

Item	Amount per Acre	Total Amount
Number of Stems	659	2,174
Volume in Cubic Feet	5,470	18,044
Volume in Cubic Meters	155	511
Total Net Weight in Pounds	137,085	452,381
Average Bone Dry Unit Percentage	.669	.669
Total Bone Dry Pounds	91,710	302,643
Total Bone Dry Units (pounds/2400)	38	126
Sawlogs in Scribner Board Feet	1,615	5,330

PRODUCTION RATES

The tables in this section list production rates in terms of stems per hour for various phases of the operation. Two primary types of hour figures are used. The first is that time in which the crew or machine was actually operating and the second encompasses both operational time plus associated working time including breakdown and changing the skyline corridors. For purposes of this analysis I am assuming a rigging time per set of 1.5 hours without the intermediate support and 3.0 hours with the intermediate support. The remaining times were actual field measurements. These figures do not reflect nonproductive time such as lunch breaks, travel time or record keeping. Although production rates are based on stems per hour, they can be converted to cubic feet by using a multiplier of 8.3.

Felling and Bunching:

The crews worked a total of 74.45 crew hours (including breakdown) and fell 2,177 trees for an average of 68 stems per crew hour or 29 stems per crew member hour. In the two person crews the average was 63 stems per crew hour and 31 stems per crew member hour. By contrast when there were three people in the crew, the crew production increased to 83 stems per hour but the production per crew member fell to 27 stems per hour. These figures are significantly higher than the 12.3 stems per crew member hour on Treatment Plot 4. Two factors contributed to the increased production on Treatment Plot 6. First, because this was a clearcut, the crews did not have to work around leave trees or have delays

with tree hangups. Second, the crews did not lose time working around the skyline or changing from one side of the skyline to the other. Although we have no way of measuring it directly, the clearcut felling appears to be the most significant of the two factors. The stem count of 2,177 includes only those trees which the crew estimated would be removed from the stand. In addition the crews cut approximately 148 live trees and 197 dead trees per acre (345 total) in the two through four inch diameter breast high classes. This totaled 1,138 stems on the 3.3 acre block that were cut but not removed from the stand. The crews also cut many deadfalls and leaning trees which were not counted. In fact, the crews estimated that of the 74.45 crew member hours spent falling, about one half of the time was spent cutting either small trees or material on the ground. The crews averaged 241 cubic feet or 6.8 cubic meters per crew member hour.

Yarding:

The following table lists in summary form the major data from the yarding phase of the operation:

YARDING PRODUCTION

Item	Amount
Yarder crew	3
Total stems yarded	2,130
Average yarding distance in feet	330
Total turns	639
Average number of stems per turn	3.3
Skyline corridor settings	3
Yarder operational hours	31.1
Yarder downtime (cable repair, moving stop, etc.), hours	1.49
Yarder setup time, hours	7.5
Total yarder time, hours	40.9
Total crew time, hours	133.17
Yarder fuel used, gallons	34.8
Average fuel use per hour, gallons	1.12

The Yarding Production Table does not include the first 1.5 hours of yarder operation when the crew moved 14 drags and 44 stems. This was a trial period to determine if limbing and topping the trees in the woods during the inhaul phase was feasible. After this brief test in which the crew yarded only 29 stems per hour, we abandoned this approach. Therefore the data was not included. The values listed in the table are the combined average production rates of the three and four person crews. We used the four person crew only 28 percent of the time and their production rate averaged 10 trees per hour less than that of the three person crew. Because the larger crew was used only on the lower portions of each corridor, we feel that production rates were more closely correlated with average yarding distance rather than crewsize. It was not necessary to have a third person in the woods.

The yarder crew moved an average of 68 stems per operational hour and 53 stems per working hour on this plot. The production rates varied from 88 stems per operational hour on the upper portions of the strip to 50 stems per operational hour on the lower portions. On a crew member hour basis we yarded an average of 21 stems per operational hour or 16 stems per working hour. The crew yarded an average of 440 cubic feet per working hour. Finally it is interesting to note that of the 40.09 total yarder working hours, 19 percent of the time was spent in setup and rigging.

Swing and Processing Phase:

The skidder operator worked a total of 30.06 hours in the swing phase of the operation. During this time he removed 639 turns and 2,130 trees from the Clearwater Yarder to the processing area for an average of 71 trees per hour. The other crew members (either one or two) spent a total of 39.15 hours limbing, bucking and topping the trees. On the first corridor one of the crew members used the farm tractor for 5.61 hours to move the processed logs to the decking area. The 440 operator decked the logs from the remaining corridor below the road near the processing area. The John Deere Model 440 grapple skidder used an average of 1.25 gallons of fuel per hour and the John Deere Model 2940 farm tractor used .95 gallons per hour.

TECHNICAL TRANSFER

Once again foresters from both the Division of Forestry and Champion Timberlands viewed the operation. In addition personnel from the Montana Department of Natural Resources and Conservation inspected the area and used video tape to document and record various aspects of the yarding. We also presented a formal demonstration to 26 members of the Northern Rockies Stand Management Council, a group of professional land managers from eastern Washington, northern Idaho and western Montana. Many of these individuals requested further information on our projects for potential use in their local areas.

BITTERROOT MINIYARDER ON TREATMENT PLOT 6

PLOT LOCATION, DESCRIPTION AND LAYOUT

The Miniyarder unit is located on the eastern edge of Treatment Plot 6. The plot contains 0.62 acres, is approximately 50 feet wide and extends down the hill a horizontal distance of 460 feet. The length of the corridor was limited by the amount of skyline on the Miniyarder. It took three people 2.1 hours to set up the Miniyarder on the road and rig the skyline complete with intermediate support jack as described in the previous section of this report. We used a John Deere Model 2240 grapple equipped farm tractor to move the trees from the yarder to a processing/decking area which was located on the road 100 feet from the yarder. The prescription on this unit was similar to that on the rest of Treatment Plot 6. Because the Miniyarder has less pulling capacity than the Clearwater, we were forced to yard smaller trees just to access the pulpwood-sized stems. As a result, we feel that the average tree removed contained approximately 7.6 cubic feet rather than the 8.3 cubic feet per tree on the Clearwater portion of the plot. However the stand table data for Treatment Plot 6 is valid for this subunit.

PLOT TREATMENT

We installed this unit to compare production rates - and ultimately operational costs - between the Clearwater and Bitterroot yarders. As such, we tried to treat this portion of the plot in the same way we had done the initial three corridors. We used two crews, each consisting of a sawyer and pusher, to fall the trees on the unit. Once again the crews started at the bottom of the strip and worked side by side up the hill with each crew responsible for approximately a 25 foot wide swath. As in previous areas felled for the Miniyarder, the crews bucked the larger trees into sections for yarding.

For the first time in this project we used only two people on the yarding crew, the operator and one hooker in the woods. We felt that this crew size would be optimum for a number of reasons. First, because this was a clearcut breakaway blockw would not be needed. Second, the corridor was only 50 feet wide so we would not have extreme lateral yarding distances. Third, with the reduced pulling capacity of the Miniyarder, we could only use two to three chokers which would be easy for one person to handle. Fourth, the slower inhaul speed of the Bitterroot would enable the one person to preset chokers in most cases. We rigged the intermediate support jack on two eight inch DBH lodgepole pine and these trees worked very well without additional guy lines. The tail hold was placed approximately 30 feet from the ground on an 16 inch DBH western larch. This size tree proved more than adequate for the tailhold.

One person did the entire swing and processing phase of the operation using a 5Ø horsepower, four wheeled drive, grapple equipped farm tractor. This was feasible because the yarding capacity of the Bitterroot was well matched to the skidding capacity of the farm tractor. Also the processing and decking area was immediately adjacent to the yarder so the tractor operator had very short skidding distances. After two to four trees accumulated under the yarder, the tractor operator would swing them on the road. After limbing and topping the trees, he decked the logs on the downhill side of the road and pushed the slash into a large pile near the log deck. As expected, the operator had to work very fast and efficiently to avoid falling behind. This was particularly true when the upper one quarter of the corridor was being yarded, and on a few occasions the yarder operator assisted with the limbing and topping. In general however, the one person was very efficient and cost effective for the swing and processing phase.

The following table lists a summary of the roundwood material removed from this .62 acre portion of Treatment Plot 6:

ROUNDWOOD MATERIAL REMOVED

Item	Amount Removed
Number of Stems	388
Volume in Cubic Feet	2,949
Volume in Cubic Meters	83
Total Net Weight in Pounds	54,3ØØ
Average Bone Dry Unit Percentage	.669
Total Bone Dry Pounds	36,327
Total Bone Dry Units (pounds/24ØØ)	15.14

PRODUCTION RATES

The types of hour figures used in this section are the same as in the Clearwater portion of Treatment Plot 6. All the times used in the various phases of the operation were actually measured in the field. Again, although production rates are based on stems per hour, they can be converted to cubic feet by using a multiplier of 7.6.

Felling and Bunching:

The two crews each worked for 3.66 hours or a total of 14.64 hours for the four people. They fell a total of 3Ø1 pulpwood-sized trees for an average of 41 stems per crew hour or 21 stems per crew member hour. Once again the total stem count does not include trees smaller than five inches DBH or windfalls that had to be sawn. Based on the stand table there were approximately 214 small trees felled, but not counted, on this plot. The crews averaged 16Ø cubic feet or 4.5 cubic meters per crew member hour.

Yarding:

The following table lists in summary form the major data from the yarding phase of the operation:

YARDING PRODUCTION

Item	Amount
Yarder crew	1
Total stems yarded	388
Average yarding distance in feet	275
Total turns	296
Average number of stems per turn	1.3
Skyline corridor settings	1
Yarder operational hours	12.67
Yarder downtime (cable repair, moving stop, etc.), hours	.25
Yarder setup time (including intermediate support), hours	2.1
Total yarder time, hours	15.Ø2
Total crew time, hours	32.14
Yarder fuel used, gallons	13.9
Average fuel use per hour, gallons	1.1Ø

The two person yarding crew moved an average of 3Ø stems per operational hour and 26 stems per working hour. The production rates per operational hour varied directly with the distance down the corridor. For example, in the four timekeeping periods, the

production per operational crew hour decreased from the top of the strip to the bottom in the following manner: 38 stems, 30 stems, 28 stems and 25 stems. On a crew member hour basis, we yarded an average of 15 stems per operational hour and 12 stems per working hour. These figures compare to 21 stems and 16 stems respectively with the Clearwater on the rest of Treatment Plot 6. The crew yarded an average of 198 cubic feet per working hour with the Miniyarder or 91 cubic feet per working crew member hour. By contrast, the crew averaged 133 cubic feet per working crew member hour with the Clearwater yarder.

Swing and Processing Phase:

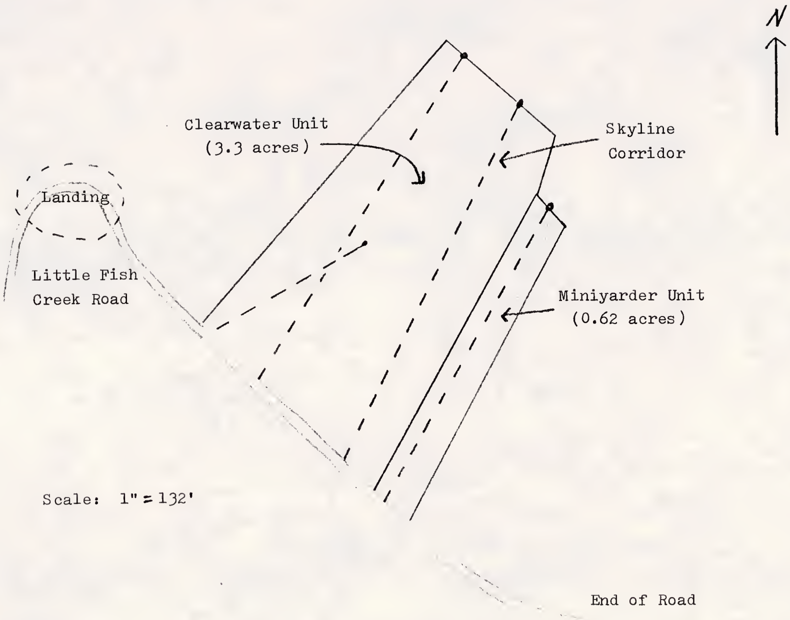
The one person worked 13.34 hours in the swing and processing phase of the operation. During this time he skidded and processed 296 turns and 388 trees for an average of 29 trees per hour. The working time also includes slash piling and decking the pulplogs. The John Deere Model 2240 farm tractor used an average of .75 gallons of fuel per hour.

TECHNICAL TRANSFER

Although we conducted no formal demonstrations on this unit, the production data will be included in project brochures and the final report.

TREATMENT PLOT 6

MILESTONE #9



APPENDIX H

EQUIPMENT SPECIFICATIONS

PACIFIC MODEL 550S TRACTOR WINCH

Mounts:	On tractors from 20 - 100 horsepower (hp) with Category 1 and 2 three point hydraulic hitch and power takeoff (pto) Universal joint drive shaft with non-rotating guard
Cable Pull:	12,000 pounds (lbs)
Cable Speed:	120 - 430 feet per minute (fpm) with 540 revolutions per minute (rpm) at the pto
Cable Drum Capacity:	15/32 inch - 160 feet 3/8 inch standard - 300 feet 11/32 inch - 340 feet 5/16 inch - 500 feet 1/4 inch - 750 feet
Clutch:	Heavy duty, air cooled
Drive:	Double roller chain

For more information, contact:

Pacific Winches
P.O. Box 164
Lynden, WA 98264

BITTERROOT MINIYARDER

Weight:	1,600 lbs rigged
Engine:	18 hp Briggs & Stratton, twin cylinder, air cooled, electric start, remote fuel tank
Transmission:	Sundstrand series 15 hydrostat
Axle:	Dana Spicer GT-20 with 72-tooth spurgear
Skyline & Main Drums:	800 feet of 1/4 inch cable or 600 feet of 3/8 inch cable 0 - 2,000 lbs line pull 0 - 400 fpm line speed
Mainline Clutch:	Dog type
Brakes:	Band type, mechanically operated, 12 & 3/5 inch diameter
Boom:	2 & 1/2 inch pipe A-frame, 17 & 1/2 feet long, 180 degree fairlead swivel, manually raised and lowered
Controls:	15 foot mechanical push/pull cable

For more information and copy of plans, contact:

USDA Forest Service
Equipment Development Center
Bldg. 1, Fort Missoula
Missoula, MT 59801

CLEARWATER YARDER

Weight:	13,500 lbs
Engine:	Detroit Diesel Allison, 3-53N rated 97 bhp at 2,800 rpm
Transmission:	Hydrostatic, Dynapower pumps with Hagglud and Soner wheelmotors, 300 rpm maximum drum speed
Brakes:	Drum type, hydraulically operated
Live Skyline:	800 feet of 1/2 inch cable 7,500 lbs maximum line pull 0 - 500 fpm line speed
Mainline:	900 feet of 3/8 inch cable 3,500 lbs maximum line pull 0 - 1,000 fpm line speed
Haulback:	1,800 feet of 3/8 inch cable 3,500 lbs maximum line pull 0 - 1,000 fpm line speed
Mast:	10 inch by 10 inch by 1/2 inch wall square tubing, 170 degree fairlead swivel, hydraulically raised and lowered
Control:	12 volt dc over hydraulic

For more information and copy of plans, contact:

USDA Forest Service
Equipment Development Center
Bldg. 1, Fort Missoula
Missoula, MT 59801

JOHN DEERE MODEL 224Ø 4WD FARM TRACTOR

Horsepower:	5Ø maximum pto with engine at 25ØØ rpm
Engine:	Valve-in head, wet sleeve, variable speed diesel
Type:	3 cylinder
Operating Range:	15ØØ - 25ØØ rpm
Compression Ratio:	16.7:1
Displacement:	179 cubic inches
Fuel Tank Capacity:	2Ø.6 gallons
Transmission:	Top-shaft synchronized, 8 forward and 4 reverse speeds
Brakes:	Hydraulical, foot operated, individual or simultaneous operation
Hydraulic System:	Closed-center
Steering:	Power
Power Takeoff:	Standard - continuous, 54Ø rpm rear Optional - independent, hydraulically actuated, 54Ø rpm rear
Weight:	4,74Ø lbs
Dimensions:	
Hood Height:	55.8 inches
Length:	126.7 inches
Width (min):	67.5 inches
Wheelbase:	74.2 inches
Turning Radius:	11Ø inches

JOHN DEERE MODEL 2940 4WD FARM TRACTOR

Horsepower:	80 maximum pto with engine at 2500 rpm
Engine:	Valve-in head, wet sleeve, variable speed diesel
Type:	6 cylinder
Operating Range:	1500 - 2500 rpm
Compression Ratio:	16.8:1
Displacement:	359 cubic inches
Fuel Tank Capacity:	33.3 gallons
Transmission:	Top-shaft synchronized, 8 forward and 4 reverse speeds
Brakes:	Hydraulic, foot operated, individual or simultaneous operation
Hydraulic System:	Closed-center
Steering:	Hydrostatic
Power Takeoff:	Independent, hydraulically actuated, 540 - 1000 rpm rear
Weight:	9,347 lbs
Dimensions:	
Hood Height:	66.1 inches
Length:	164.9 inches
Width (min):	90.3 inches
Wheelbase:	100.4 inches
Turning Radius:	185 inches

JOHN DEERE MODEL 44Ø GRAPPLE SKIDDER

Horsepower:	Net 7Ø with engine at 22ØØ rpm
Fuel Tank Capacity:	42 gallons
Transmission:	Constant mesh with 6 speeds forward and 3 reverse
Brakes:	Hydraulic, power actuated
Hydraulic System:	Closed-center, constant pressure
Power Steering:	Hydraulically actuated
SAE Operating Weight:	16,525 lbs
Overall Width:	92.4 inches
Wheelbase:	1Ø6 inches
Turning Radius:	35 feet 5 inches
Travel Speeds:	2 - 15 mph
Grapple Opening:	75 inches maximum
Winch Linepull:	
Bare Drum:	23,9Ø6 lbs
Full Drum:	14,711 lbs

JOHN DEERE MODEL 540 GRAPPLE SKIDDER

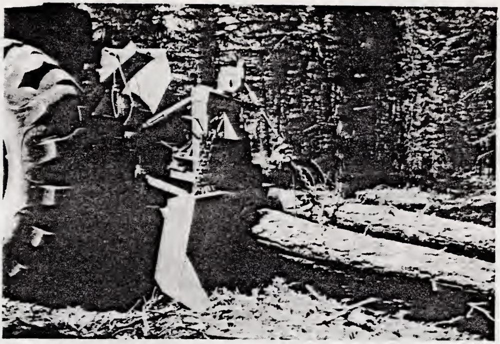
Horsepower:	Net 90 with engine at 2200 rpm
Fuel Tank Capacity:	42 gallons
Transmission:	Constant mesh with 6 speeds forward and 2 reverse
Brakes:	Hydraulic, power actuated
Hydraulic System:	Closed-center, constant pressure
Power Steering:	Hydraulically operated
SAE Operating Weight:	18,675 lbs
Overall Width:	105 inches
Wheelbase:	106 inches
Turning Radius:	34 feet 5 inches
Travel Speeds:	1.7 - 17.9 ph
Grapple Opening:	75 inches maximum
Winch Linepull:	
Bare Drum:	30,514 lbs
Full Drum:	18,794 lbs

MORBARK MODEL 12 TOTAL CHIPARVESTOR

General:	
Width:	16 feet 6 inches
Height (with cab):	12 feet
Weight (with cab):	13,500 lb
Feed System:	Hydraulic power compression feed rolls
Side Rolls:	Length - 21 inches, diameter - 8 inches
Top Feed Rolls:	Length - 24 inches, diameter - 8 inches
Feed Rate:	
5/8 inch Chip:	65.4 feet per minute (fpm)
3/4 inch Chip:	78.7 fpm
7/8 inch Chip:	92 fpm
1 inch Chip:	105.3 fpm
Power Unit:	John Deere 6466A
Engine Type:	Diesel
Horsepower:	210
Fuel Tank Capacity:	45 gallons
Chipper:	40 inch, 2 knives, 12 inch maximum opening
Loader:	Morbark Model SS25
Boom Reach:	13 feet
Swing	90 degrees
Standard Equipment:	Four wheel compression infeed system, top and bottom rolls are adjustable up and down
	Trailer hitch is a 3 inch Lanet with integrated braking system
	Manual swivel discharge spout
	Single axel suspension, dual wheel 8.75 x 16.5 - 10 ply rating

APPENDIX I

SELECTED PHOTOGRAPHS OF OPERATIONS



The Pacific Tractor Winch attaches to the 3-point hitch of a conventional farm tractor and is powered by the power-take-off shaft.

The Pacific Winch yarding and cold-decking stems perpendicular to the road on Treatment Plot 2.

The Bitterroot Miniyarder operating on Treatment Plot 6(a).

The grapple equipped farm tractor was used to move material from the winch or yarders to a processing area.

The Clearwater yarder with a turn of lodgepole pine on Treatment Plot 6. The grapple skidder at the lower right of the photo skidded trees away from the yarder.

The standard Christy carriage and carriage stop used with both the Clearwater and Miniyarder.

This model of the Christy carriage is designed to pass over an intermediate support jack which is rigged between two trees.

To minimize damage to the residual stand, breakaway blocks were used to guide turns into the skyline corridor on Treatment Plots 3 and 5.

APPENDIX J

TECHNOLOGY TRANSFER ACTIVITIES

TECHNOLOGY TRANSFER ACTIVITIES

Technology transfer was accomplished by a wide range of activities including on-site demonstrations, off-site demonstrations, articles in newspapers and trade magazines, formal papers and talks to professional organizations, signs and brochures.

A variety of people ranging from students, landowners, contractors, professional foresters and scientists viewed the thinning system in operation at the Lubrecht Forest and vicinity. The following table lists the demonstrations given as part of this project.

	Group	Number of Participants
1.	Public Field Day	46
2.	Forestry Alumni Tour	27
3.	Northwest Science Association	17
4.	Geraldine High School Students	11
5.	Dean's Advisory Council	19
6.	Association of Western Forestry Clubs	9
7.	Sauerkraut Creek Demonstration	32
8.	American Pulpwood Association (Western Chapter)	50
9.	National Council of Forestry Researchers	15
10.	University of Montana Forestry Students	70
11.	Forestry Center Dedication Tour	17
12.	DNRC and Bonneville Power Administration Tour	10
13.	Salish Kootenai Community College	12
14.	Resource Evaluation Program	21
15.	Rancher - Landowner Workshop	27
16.	Inland Empire Stand Management Council	32
17.	Utah Landowners	4
18.	Montana Tree Farmers	54
19.	Republic of China Foresters	7
20.	Silviculture Class	20
21.	USDA Forest Service	11
22.	Rural Area Development Council	15
23.	Western Forestry Schools Conclave	12
24.	Informal Tours and Drop-ins	44
	TOTAL	582

The Project Manager took the grapple-equipped farm tractor, a photo display, slides, brochures and information to the Western Montana Fair in Missoula from August 24 - 28, 1983. In April 1986, we took the grapples, photo display and information to a demonstration, <u>Small Harvest Equipment in Action</u>, sponsored by the Washington Farm Forestry Association and others in Spokane, Washington. The Pacific Skidding Winch and the Bitterroot Miniyarder were among the harvesting units demonstrated.

Three Montana newspapers printed articles dealing with the thinning and utilization system used in this project. They were: (1) the Helena Independent Record - July 31, 1983; (2) the Lincoln weekly newspaper - July, 1983 and (3) the Meagher County News - May 30, 1985. The January, 1983, edition of The Log, a industry trade journal published in Portland, Oregon, contained an article on the thinning operations by Potter Logging and Lubrecht. Another trade journal, Timber West, is preparing a feature on the Bitterroot Miniyarder which will be published in April, 1986.

Results from this project will form the basis of three formal presentations given in 1986 by the Project Director, Hank Goetz. The presentations will be to: (1) the Northern Rockies Stand Management Council Meeting in Kalispell on June 12, 1986; (2) the Management of Small-stem Stands of Lodgepole Pine, a workshop sponsored by the Intermountain Research Station, the U.S. Forest Service and the Society of American Foresters at Fairmont Hot Springs on June 30 to July 2, 1986 and (3) Future Forests of the Mountain West -- A Stand Culture Symposium, held at Missoula from September 29 to October 3, 1986. Formal papers will be published in conjunction with the last two presentations.

Permanent public information signs will be erected at Treatment Plots 1 and 5. The signs will briefly describe the operation at each site, and will complement written handouts. These sites will be used in the future to show the type of thinning that can be done with small cable systems. A informational brochure about the project is being prepared for circulation to the general public. The brochure will be distributed at the Lubrecht Forestry Center, by the Forestry Division of the Montana Department of State Lands and by the state Extension Forester.

GLOSSARY

GLOSSARY OF FOREST ENGINEERING TERMS

A

anchor cable. -- A line used to steady a yarder to prevent tipping on a heavy pull.

B

basal area. -- The cross-section area of a tree at breast height, including bark.

bell. -- A type of choker hook.

bight. -- The middle part of a slack rope, also a loop or bend in a rope.

block. -- A wooden or metal case enclosing one or more pulleys used to lead a line in a specific direction, and provided with a hook, eye, or strap by which the unit may be attached to an object.

bole. -- The trunk of a tree, especially the lower merchantable portion.

breakaway block. -- A self-releasing snatchblock. The snatchblock has a spring-loaded clip that holds the cable on the sheave until the clip is tripped by the load. *

break out. -- To get a log out of a hang-up or out of its initial lay on the ground.

buck. -- To saw felled trees into log lengths.

bull hook. -- A hook for attaching chokers to a line.

bunch. -- To assemble logs in a load for subsequent transport.

butt. -- The base of a tree stem.

Note: Those definitions marked with an asterisk (*) were developed by Lubrecht Forest personnel. All others were taken from the following reference.

Mifflin, Ronald W. and Hilton H. Lysons. 1979. Glossary of Forest Engineering Terms. 24 p. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

C

cable logging. -- A yarding system employing winches in a fixed position.

cableway. -- A transporting system typically consisting of a cable suspended between elevated supports so as to constitute a track along which carriers can be pulled.

carriage. -- A load carrying device from which logs are suspended which rides up and down the skyline on sheaves for yarding or loading. Also "skyline carriage."

carriage stop. -- A device that clamps on the skyline. The stop halts the travel of the carriage, locks it to the skyline, and automatically trips a cam to release the mainline. *

chase. -- To unhook chokers from logs at the landing.

choker. -- A noose of wire rope for hauling logs.

choker setter. -- One who puts a choker around a log and attaches it to a line or butt rigging.

chord. -- A straight line between skyline support points.

clearcut. -- To remove the entire stand in one cutting, also an area harvested in this manner.

cold deck. -- A stack of logs left for later transportation.

compact. -- To increase the density of soil by moving heavy equipment over it, or tamping it.

corridor. -- A cleared strip through which a skyline is operated. Also "skyline corridor."

cross support. -- A lateral line used to provide intermediate support for a multispan skyline.

crown. -- The upper part of a tree, consisting of the main branch system and foliage.

cruise. -- To inventory a forest stand to determine the quantity of forest products available from it. Cruise data may include tree and site quality, tree size, stand age and density, species, growth rate, topography, and logging possibilities.

D

D.b.h.. -- Or "dbh," diameter breast height, normally measured outside the bark at 4.5 feet from the ground. *

deck. -- A stack of logs, also to stack logs.

deflection. -- The vertical distance between the chord and the skyline, usually measured at midspan and expressed as a percentage of the span. Also called "sag."

directional felling. -- Felling trees according to a predetermined pattern of lay on the ground. It may involve jacking or pulling the trees.

F

fairlead. -- A device that consists of pulleys or rollers arranged to permit reeling in a cable from any direction.

fall. -- See "fell." Note: "Fall" and "faller" are often used interchangeably with "fell" and "feller."

faller. -- A logger who fells timber.

fell. -- To cut down trees. Also "fall."

G

grapple. -- A hinged set of jaws capable of being opened and closed, used to grip logs during yarding or loading.

gravity logging. -- Any cable ystem that depends on the force of gravity for downhill travel of the carriage.

ground skidding. -- Pulling logs parallel to the ground without using an arch or fairlead to raise the forward end.

guy. -- A rope, chain, or rod attached to something to brace, steady, or guide it.

H

hang up. -- A log stuck behind a tree, stump, or other obstruction during yarding, preventing its forward movement.

hog (fuel). -- Coarsewood chips to be burned as fuel.

hook. -- To attach chokers to logs in the brush.

I

inhaul. -- The portion of a cable yarding cycle where a turn of logs is brought to the landing.

intermediate support. -- A spar tree or cable sling located between the headspar and tailspar to which a tree jack or J-bar is attached to support a multispan skyline.

L

lateral yarding. -- Any movement of logs towards the center of a yarding road.

layout. -- (a) A logging plan. (b) The position of the running lines in a cable yarding system.

lead. -- (a) The direction of the operating or main line(s). (b) A block or series of blocks or rollers attached to a stationery object to guide the cable by which logs are dragged.

line change. -- The act of rigging a new highlead or skyline yarding road. Also "road change."

live skyline. -- A standing skyline that can be raised or lowered to facilitate yarding. Also "slack skyline."

M

main line. -- The cable used to haul logs to the landing.

Mbf. -- Thousand board feet.

multispan skyline. -- A skyline having one or more intermediate supports.

O

outhaul. -- The portion of a cable yarding cycle where the rigging or carriage returns to the timber from the landing for another turn.

overstory trees. -- The trees in a forest of more than one story that form the uppermost canopy layer.

P

partial cut. -- Removal of some of the trees from a stand of timber.

perpendicular felling. -- Timber felled at right angles to ground contour lines.

pulley. -- See "sheave."

pulpwood. -- Small timber used as a fiber source in a pulpmill.

pusher. -- A person who works with the feller to manually push the falling tree in the desired direction. *

R

rigging. -- The cables, blocks, and other equipment used in yarding and loading logs.

rig (up). -- To prepare a tailhold, spar, or tower for yarding by guying and anchoring it, attaching all rigging and stringing the lines.

road. -- (a) An access and haul route for vehicles. (b) The path followed by a turn of logs skidded or yarded by a cable system. Also "yarding road." (c) In skyline logging, the area bounded by the lateral yarding distance on both sides of the skyline and the external yarding distance. Also "skyline road."

rub tree. -- A tree used as a fender or pivot to protect the remaining stand during yarding.

S

sag. -- See "deflection."

saw log. -- A log suitable in size and grade for producing sawn lumber.

selective cut. -- A type of timber harvest that removes only certain species above a certain size or value.

setting. -- The area yarded to one landing.

sheave. -- A wheel with a grooved rim. Also "pulley".

shingle stack. -- A method of decking bunches of small trees. The bunches are heeled with the tops off the ground at a 20 to 30 degree angle and backed into the stack. Succeeding bunches overlap the previous material and only the butts of each layer are in contact with the ground. *

silvicultural system. -- A process of tending, harvesting, and replacing forests which results in the production of forest of distinctive form. Systems are classified according to the method of cutting used for stand reproduction.

single-span skyline. -- A skyline without intermediate supports.

skidder. -- A self-propelled vehicle used to transport logs, generally by dragging them with a grapple or chokers.

skidding. -- Dragging logs to the landing (usually with a self-propelled vehicle.)

skyline. -- A cableway stretched tautly between two points and used as a track for a block or carriage.

skyline carriage. -- See "carriage."

skyline corridor. -- See "corridor."

skyline deflection. -- See "deflection."

skyline logging. -- A logging method in which a block or carriage rides on a skyline.

skyline slope. -- The slant or inclination of the skyline chord, generally expressed as a percentage.

skyline tieback. -- A guyline attached to the carriage stop which restricts sideways movement of the skyline during lateral yarding. Used in a thinning application to prevent damage to leave trees along the skyline corridor. *

slash. -- Woody debris remaining after logging or road construction.

sling. -- See "strap."

snatch block. -- A block that can be opened on one side to allow a rope to be laid in the block, instead of threading it through from one end.

span. -- The horizontal distance between two adjacent skyline supports.

stand density. -- A quantitative measure of tree stocking frequently expressed in terms of number of trees, basal area, or volume, per unit area.

stem. -- The main body of a tree from which branches grow. Also can refer loosely to trees. For example, "stems per unit area."

strap. -- A short cable with an eye in each end. Also "sling."

stumpage. -- the value of timber as it stands uncut.

swing. -- To move logs to a landing from a distant deck to which they have been yarded.

T

tailhold. -- (a) The anchorage at the outer end of a skyline, away from the landing. (b) A line securing a tailblock to a stump.

tailspar. -- A spar at the outer end of a skyline yarding system, away from the landing, which elevates and supports one end of the skyline.

tailtree. -- A standing tree used as a tailspar.

thinning. -- The removal of selected trees from an immature stand to stimulate or maintain desired growth.

tower. -- A steel mast or framework, generally portable, used instead of a spar tree for cable yarding.

tree length. -- Refers to unbucked, limbed and topped trees.

turn. -- The logs brought to the landing in any one yarding or skidding cycle.

U

understory trees. -- The trees below an overstory of taller trees.

unhook. -- To remove chokers from logs at the landing.

W

whole trees. -- Refers to felled trees, unbucked, with limbs and tops intact.

winch. -- A powered drum used to reel in or pay out cable for hauling or hoisting.

Y

yarder. -- A machine or system of winches used to haul logs to a landing.

yarding. -- The act or process of conveying logs to a landing. (Author's note: normally the machine is stationary and usually applied to a cable system.)